MAY 28, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Designing for Balance

Contents, Page 3

FARNSWORTH

There's 1 source for 2 way 3 way or 4 way MIDGET SOLENOID VALVES

Progressive designers, the men who lead the trend toward miniaturization, depend on ASCO as the one source for a full line of midget solenoid valves. The unexcelled quality and dependability that ASCO pioneered in the solenoid valve field is found, too, in today's midget solenoid valves. Only the size has been reduced.

For flow applications using air, gas, water, light oil, refrigerants and many other liquids, ASCO Midget Valves assure complete safety and truly exceptional performance.

ASCO Midget Solenoid Valves are available with standard, watertight or explosion-proof enclosures. Pipe sizes ⅛" and ¼"; pressure range 0-1000 psi.

There's *one* source that solves virtually any solenoid valve problem — ASCO. Write today for complete data on ASCO Midget Solenoid Valves — or outline any of your requirements. We'll be pleased to assist you.

SHOWN ¾ ACTUAL SIZE

AUTOMATIC TRANSFER SWITCHES
SOLENOID VALVES ELECTROMAGNETIC CONTROL

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54-A Hanover Road, Florham Park, New Jersey
FRontier 7-4600

ASCO

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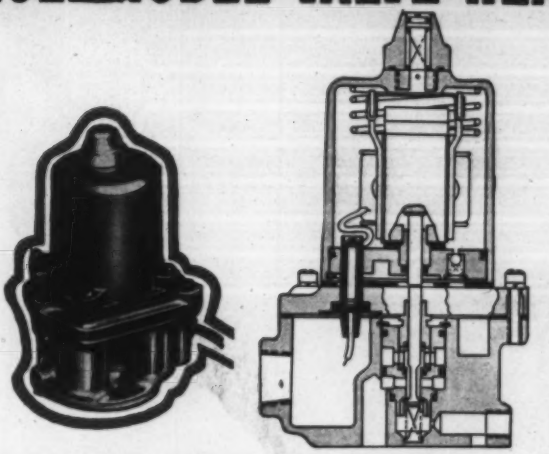
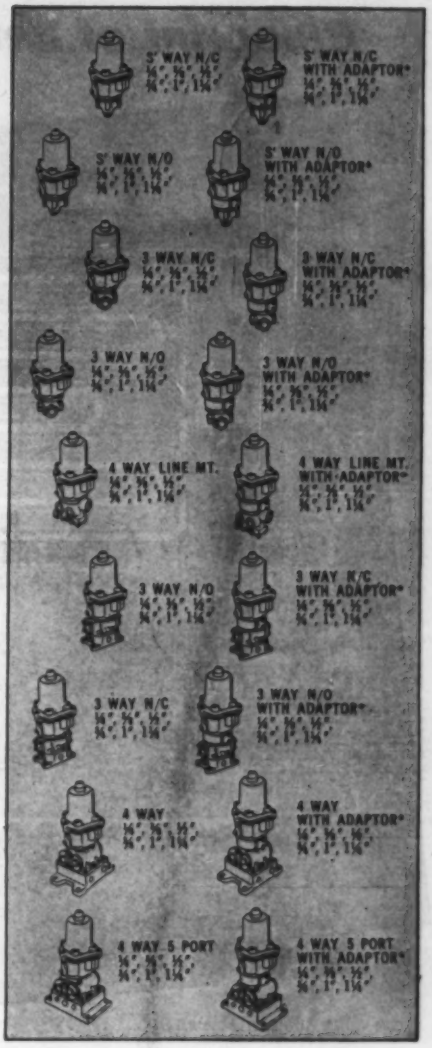
a basic Ross valve building block

GOLDMODEL VALVE HEAD

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3 WAY N/C
3 WAY N/O WITH ADAPTOR
4 WAY
4 WAY WITH ADAPTOR
4 WAY 5 PORT
4 WAY 5 PORT WITH ADAPTOR

OIL IMMERSED SOLENOID

- The finest achievement in solenoid heads
- JIC
- Over 50 million cycles in tests
- Lightning fast

Modular construction is brought to the air valve field to give you the effect of a great valve inventory without stocking a great number of valves. Stock just one of these Goldmodel heads and you have the finest solenoid actuator obtainable for any one of the 54 Skyline bodies. This is the head designed especially for those uses where dependable performance and very long life must supersede all other considerations. The dustproof solenoid is the very finest and is immersed in oil to run cool and stay young. Write for bulletin 318.

"every head meets every body at this gasket"

ALL SKYLINE HEADS AND BODIES ARE BUILDING BLOCKS TO GIVE YOU MANY VALVES FROM A FEW HEADS AND BODIES

ROSS OPERATING VALVE COMPANY

109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.

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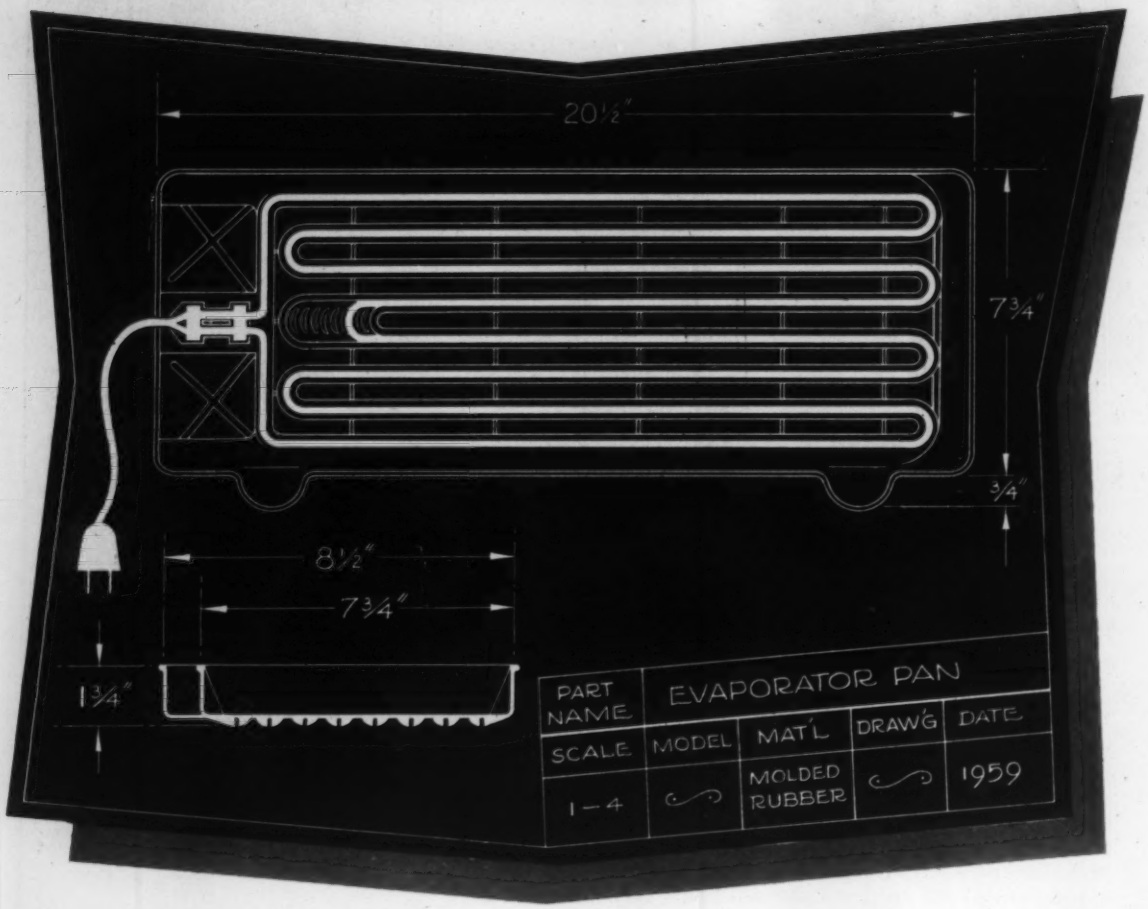
Blueprint of better design–



–for an Improved refrigerator evaporator pan

To Goodyear molded/extruded rubber specialists, the problem was typical: Develop an evaporator pan that wouldn't rattle—one that would last longer and heat more efficiently than the pans of other materials and with separate heaters then in use.

The results of the project exceeded the hopes of the big-name refrigerator maker. For the new molded rubber pan developed by Goodyear is rattleproof, rustproof, virtually indestructible. What's more, its special bottom grooving accommodates a snap-in heating unit offering one-piece compactness—plus easy removal for replacement.

So once again the skilled personnel – in the modern Goodyear molded/extruded plants – have made an important contribution to modern product design. It's a sample of what *you* can expect when you call on some of the country's outstanding rubber specialists at Goodyear.

For complete information – or an invitation to tour these plants and see their unparalleled facilities for yourself, contact your G.T.M.—Goodyear Technical Man. Or write directly to Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

MOLDED OR EXTRUDED RUBBER BY

GOODYEAR

THE GREATEST NAME IN RUBBER

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Front Cover: A "multiple-exposure" technique is used by artist George Farnsworth to illustrate the effect of unbalance in a rotating part. Article by Robert Zenk on designing for balance starts on Page 102.

May 28, 1959

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Anaconda flexible connectors of Teflon carry 40-lb. steam to centrifugal steam dryers at Chromium Process Co., Shelton, Conn.

Steam lines formerly lasted 3-4 weeks—but Hose of Teflon* by Anaconda passes 13 months, still going strong

It's a little over a year that these flexible connectors of Teflon by Anaconda have been serving The Chromium Process Company. During this period, 12 sets of rubber hose would have been required. Add to this the cost of down time and labor for replacement.

This is just another example of how flexible connectors of Teflon by Anaconda are saving time and money in tough jobs. Anaconda offers a line of standard hose assemblies and engineering services for design and development of connectors to meet special applications. Send coupon below for catalog. For technical assistance write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Connecticut. 39127

Flexible Connectors of TEFLON by ANACONDA®

*DuPont trademark for TFE-fluorocarbon resin.

Bank of three centrifugal steam dryers for drying parts which have been plated.

Anaconda Metal Hose Division
The American Brass Company, Waterbury 20, Conn.

Please send me Bulletin TC-101, "Anaconda Flexible Connectors of Teflon." MD

NAME.....

COMPANY.....

STREET.....

CITY.....ZONE.....STATE.....

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ENGINEERING NEWS

Automatic Throughways Will Let Drivers Relax

Thinking Highway Model Has Block-to-Block Control

WASHINGTON—The Chicago-to-New York toll road of the future will permit the driver to be a passenger. He would scarcely have to touch steering wheel, accelerator, or brake until he reached the Lincoln Tunnel cutoff into Manhattan, except for fuel and rest stops. A working model of such a highway has been unveiled by General Motors Corp., to highway experts.

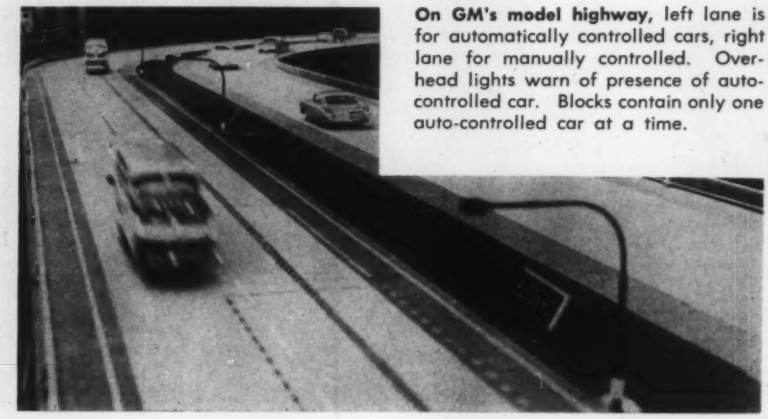
"Automatic vehicle control is progressing from the dream stage," says Dr. Lawrence R. Hafstad, GM vice president. "The techniques and knowledge are presently available."

Developed in co-operation with AR&T Electronics Inc., GM's Auto-Control system is the latest in the quest for safer, more enjoyable, and more economical motoring.

Automatic steering is accomplished by an electromagnetic system. The vehicle follows a magnetic path created by low-frequency electrical current from a cable embedded in the road. An electronic computer takes the signals from the cable and actuates a servo system to steer the car. The guidance cable in the pavement is a crisscross wire in the center of the automatic lane.

The guidance cable also provides a measure of car speed—the vehicle counts "crisscrosses per second." Another cable in the pavement provides a speed-control signal, while still other circuits regulate the speed of all vehicles for safe spacing.

Obstacle detection is accomplished by dividing the highway into 200 ft long control blocks. On the scale model, these blocks are 5 ft long. When a car is in a given block, its speed controls the speed of vehicles in the two blocks to the rear. If a vehicle stops in the automatic line, the following car is slowed down two blocks back and stopped in the first block to the rear. Also, any sizable metallic object on the road will trip the "obstacle ahead" system.



On GM's model highway, left lane is for automatically controlled cars, right lane for manually controlled. Overhead lights warn of presence of auto-controlled car. Blocks contain only one auto-controlled car at a time.

In the GM 1/40th scale working model of a four-lane divided highway, four buses are controlled by the road's electric signals. Buses roll around the 20 by 30 ft oval at speeds equivalent to full-scale speed of 30 and 60 mph. Speeds can be arbitrarily set at a control station and, on a real highway, could be varied depending upon weather conditions and other factors. All electronic components in the 11-in. buses are full size.

Cultivate Creative Mind at Student Level, GM President Tells Engineering Colleges

DETROIT—Many more intricate problems will face tomorrow's automotive engineer, says John F. Gordon, president of General Motors Corp. The vehicle designer of the future must not only produce new ideas, but he must be comfortable working in an intellectual climate of constant change.

In an article in the *Detroit Engineer*, a publication of the Engineering Society of Detroit, Mr. Gordon disclaims any deep knowledge of the problems of engineering education. However, drawing on his long experience in the engineering field, he lists ten traits which engineering education should cultivate in its students:

- A firm grasp on the fundamentals of physics, chemistry, and mathematics—as well as on the engineering and applied sciences which are basic to the branch of engineering in which the student expects his degree.
- An understanding that undergraduate education is only a foundation upon which to build additional knowledge and experience.
- Skill in the *application* of knowledge as distinguished from its acquisition.
- An understanding that engineering is largely experimental, plus the initiative to search for knowledge that is missing.
- An affinity for plain hard work.
- An understanding that in creative work failure and disappointment are common.
- Resourcefulness, imagination, and inventiveness, as well as capacity to search for reasons why something can be done instead of why it cannot.
- The ability to work effectively, both as an individual and in harmony with others.
- A command of communication techniques, including drafting as well as language.
- Awareness of the fact that opportunity and carreer success are largely a matter of self-development.

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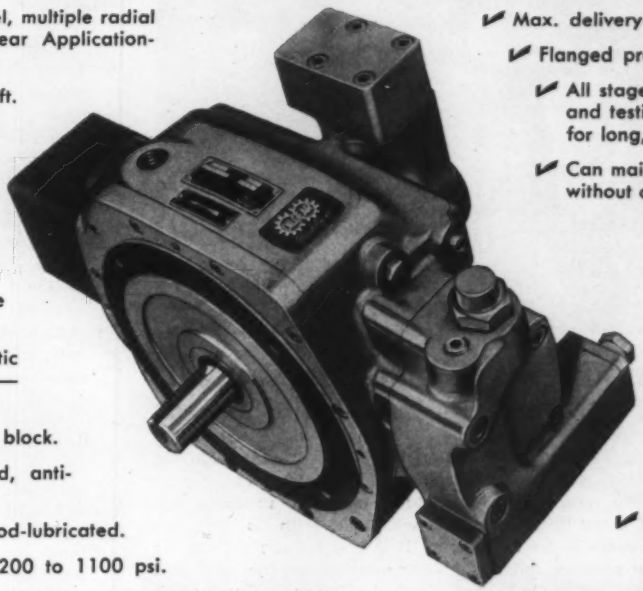
... Fluid Power news

RADIAL PISTON VARIABLE DISPLACEMENT PUMP

OILGEAR "Power-Saver" PUMPS

Type "ANP" Pumps Generate Only Needed Power —Boost System Efficiency

- Simple, one piece, alloy steel, multiple radial rolling pistons — an Oilgear Application-Proved, exclusive design.
- One-piece cylinder and shaft.
- Balanced flat valve (port plate) and separate wear plate to assure a controlled oil film between working surfaces . . . high volumetric efficiency over entire pressure range.
- Integral, adjustable volume control.
- Integral, adjustable, automatic pressure unloading control — 200 to 1100 psi.
- Precision, bearing-type slide block.
- Large, conservatively loaded, anti-friction bearings.
- Completely pressure and flood-lubricated.
- Working pressure range — 200 to 1100 psi.
- Built for continuous, full-load service on pushing, pulling, lifting, lowering applications . . . on machines requiring positive, static loads over intermittent or long periods . . . for automatic charging of accumulator systems . . . for repetitive "ON-OFF" loads up to 1100 psi. New Oilgear type "ANP" pumps will perform more efficiently — with less heat generation — on presses, machine tools, transfer machines, hold-downs, injection molding, die casting — and other machines.



- Max. delivery to 3100 cipm (13½ gpm).
- Flanged pressure and suction ports.
- All stages of manufacturing, assembly and testing under strict quality control for long, dependable service life.
- Can maintain a static load indefinitely without overload or excessive heating.
- Adjust pump volume to suit optimum ram speed — no excess oil to "wire-draw," blow past a relief valve or generate heat.
- Adjust pressure to maximum force needed. When this preset pressure is reached, control automatically reduces pump to slip stroke to save power — reduce heat.
- Available clockwise or counterclockwise rotation at no extra cost.

For complete data on these new "Power-Saver"—Oilgear type "ANP" Pumps — call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, requesting your copy of Bulletin 47550 — stating your specific requirements directly to . . .

SELECTION OF MOUNTINGS

Pump case has an accurately finished round face for:

1. Mounting direct to machine. (above)
2. Mounting to a right-angle bracket for "foot-mounting." (right)
3. Mounting to a round adapter for NEMA type "C" electric motor frames.
4. As Standard and "Custom-Built" "Power-Paks"—(right) . . . . complete, compact sources of Fluid Power. Standard "Pak" consists of "ANP" Pump with round adapter or right-angle bracket, coupling, electric motor, 23-gallon differential capacity welded steel base, piping, air breather, filling strainer, fluid level gauges, baffles, clean-out covers, drain plugs, auxiliary pipe connections, and mounting and leveling lugs.

Oilgear's *"Power-Saver"* Pumps and simplified circuitry reduces engineering, production and assembly costs . . . promotes safety, improves performance and system efficiency.

THE OILGEAR COMPANY

Application-Engineered Controlled Motion Systems

1568 WEST PIERCE STREET MILWAUKEE 4, WISCONSIN

Operator Doubles as Airframe in Rocket-Powered VTOL

Powered by two 150-lb thrust gimbaled rockets, Aerojet General's liquid-fuel Aeropak may convert infantrymen to temporary VTOL vehicles. The strap-on device is capable of lifting a 240-lb man to a height of 2200 ft—although the maneuver is not recommended. At more reasonable altitudes, however, it permits the operator to hover, fly vertically or horizontally, and land smoothly. The operator regulates angle of thrust (flight direction) with a lever in his left hand and throttles speed with a valve in his right hand. Fuel is a hydrogen peroxide monopropellant forced under pressure through a silver mesh screen that acts as a catalyst and converts the fuel into superheated steam and oxygen. Combustion temperature is 1300 F, but exhaust drops to 100 F a few feet behind nozzles.

Russian-to-English Machine Translator Yields Practical, Not Elegant Sentences

NBS Computer Makes Sense With Good, Gooder, Goodest

WASHINGTON—Experiments at the National Bureau of Standards have pointed the way to practical language translation by machine. A recently developed translation scheme instructs an electronic computer to weld together equivalent English from Russian text in a meaningful reproduction of the original sentence. Feasibility studies have been successful.

Problems of translating from one language to another, say Bureau experts, are not completely solvable. A translated sentence does not always successfully express a thought. The translator's task is to render possibly distorted statements into sentences which convey the intent and import of the original. With the additional requirement that the task be automatized, problems become quite formidable. What has been attempted at the Bureau is *practical* translation. Such translation may be

Topics

Pinball-machine playing and astronautics, ordinarily not regarded as related sciences, may share a factor that will benefit the latter. Experiments conducted with pinball-like machines show that a man learns more and performs routine tasks with greater skill when he can see or hear how he is doing. Thus, a space traveler is likely to be less subject to alertness-crippling boredom if he has access to continual feedback of information on the quality of decisions he makes in operating his controls. Prof. Paul M. Fitts, University of Michigan psychologist, experimented with a decade counter hooked up to a simple tracking device. The closer subjects were able to keep the tracking device on target, the more lights flashed on the counter. One group, receiving little information on how they were doing, stayed on target only 40 to 50 per cent of the time. With feedback increased, a second group was on target from 50 to 65 per cent of the time.

• • •

Preserving goal posts is the object of an invention inspired by enthusiastic college students who celebrate their teams' victories by destroying this part of the equipment. The inventor has developed an electric-powered system whereby retractable goal posts sink into casings in the ground; the cross-bar rests in a trench. Reversing the motors causes gears to raise the post.

• • •

A sound beating administered to coffee beans improves flavor and aroma because roasting time is reduced. Dried coffee beans are placed in a water tank and bombarded for a few minutes with sound waves in the audible or supersonic range. Such treatment breaks down the fibrous interior of the beans and pricks holes in the shells.

• • •

Small aid to the missile program is offered by the Little People of America, an international organization of midgets. They have appealed to the U. S. government to consider allowing a midget to man a rocket. Obvious advantages are reduced weight and space requirements. Psychological adaptation should pose less of a problem too, according to LPA's vice president—he says that no midget has claustrophobia, or he couldn't go out on the street "to be shut in and towered over by all those big people."

• • •

Studying the shape of nuclei of invisible atoms, seemingly a difficult task, has been undertaken by the National Bureau of Standards. Method consists of bombarding the atoms with x-rays. Nucleus of the gold atom is very symmetrical, while the tantalum nucleus is highly deformed.

Fewer replacements, farther between

...with these LINK-BELT conveyor and elevator chains

LINK-BELT C CLASS CHAIN combines cast malleable center links with steel sidebars connected by steel pins. Broad tops and bottoms provide ample sliding surfaces for drag conveyors. Also available with Promal or "file-hard" Promal center links for extreme loads and abrasive wear. Promal is the special Link-Belt metal that lasts much longer . . . costs but little more.

LINK-BELT SS CLASS BUSHED CHAIN. If your conveyor or elevator must be lengthened, or load increase accommodated, you can install this all-steel chain in place of C Class *without changing sprockets!* It offers hardened joint bearing surfaces for greater wear resistance in heavy-duty conveying and elevating. Smooth, tough joint surfaces repel gritty materials, prevent packing, and resist abrasion.

Full information on these chains . . . plus a broad line of attachments — is contained in Catalog 1050. Get your copy by writing direct . . . or call your nearest Link-Belt office, listed under CHAINS in the yellow pages of your local Phone Directory.

LINK-BELT

CHAINS AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

15,068

Circle 408 on Page 19

incomplete, but it conveys the gist of the source material intelligibly and faithfully.

The method consists of two parts. First, the machine merely "looks up" every source word in a Russian-English glossary stored on magnetic tape. Since Russian is a highly inflected language, only stems are kept in the glossary. Prefixes and suffixes are stored separately. To conserve limited memory space, refinements of English grammar are not used. All words are treated as regular, for inelegant expressions such as "gooder" or "goodest" are clear in intent.

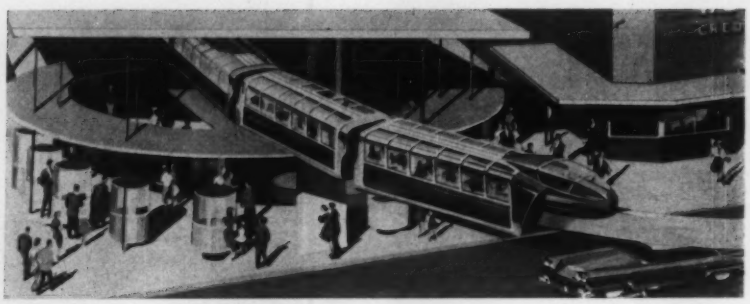
The data from the look-up, combined with that obtained for the ending of a source word, are used in the second step to weld individual target words together.

The scheme works because most words have ascertainable tendencies to associate with other words. These tendencies are listed in the glossary along with the properties of each stem. As source occurrence is examined, predictions are made concerning the occurrences expected. The scheme links words which seem to fit each other and carefully records doubts, conflicts, and indecisions that arise. By alternately looking forward to predict and backward to check previous conflicts, words are modified and rearranged in the manner of jig-saw pieces, to complete the puzzle.

If a prediction has not materialized, the next prediction will be aided by the facts previously gathered. A limit is enforced on the number of allowable repeats, since it is otherwise possible to obtain an endless repetitive process. In case of failure, a word-to-word translation is printed with an indication of where the scheme failed.

Even with no indications of failure, it is not at all certain that the final sentence is accurate. But since English is far less sensitive to variation than is Russian, the majority of English sentences should be meaningful and faithful.

With the improvements and shortcuts that are expected to be developed in the programming, and by using advanced computers now under construction, the cost may be reduced to no more than a human translator charges.



Seattle Transit Goes Monorail

First monorail to solve a city's mass transportation problem will be part of Century 21, Seattle's 18-month international exposition featuring "man in space." Contracted to Lockheed Aircraft Corp., Burbank, Calif., monorail airtrains will whisk passengers from downtown to the fairgrounds in 94 sec, traveling at speeds up to 60 mph. The system will cost about $5 million and will pay for itself during the fair, says the Seattle Transit Commission. Three airtrains, supporting structures, and terminals will be completed by November, 1960, six months before the exposition opens.

U. L. Takes the Heat off Plastics in Appliances

Plastics and Appliancemakers Happier After April 30 Meeting

CHICAGO—A turbulent series of discussions on plastics in appliances, with Underwriters' Laboratories on one side and various plastic and appliance manufacturers on the other, has ended amicably. The debate started earlier this year when U. L. issued Bulletin 484 proposing dire restrictions on the use of burnable plastics in room air conditioners. The Bulletin also summed up U. L.'s opinion that combustible plastics are replacing noncombustible materials at "an alarming rate" in all appliances.

A top level meeting on April 30 between all of the organizations and companies concerned resulted in the issuance of this memorandum by U. L. officials:

> "The proposed requirements on air-conditioning equipment have apparently been widely interpreted as a move on the part of Underwriters' Laboratories Inc. to eliminate the use of slow burning plastics in listed equipment. This was not the intent.
>
> "Underwriters' Laboratories is concerned solely with the hazard of materials as used in equipment, regardless of the materials. Any manufacturer of air-conditioning equipment to be submitted for investigation, with a view towards listing, is privileged to propose any materials he sees fit, and those materials will be judged by the Laboratories on the basis of the fundamental policy just mentioned. If, however, the manufacturer is planning to substitute combustible material in equipment where noncombustible material has been used previously, it would be desirable to submit this equipment in preliminary form prior to tooling for production, to avoid expensive changes should changes be found necessary."

"With specific reference to the proposed requirements in Bulletin 484, U. L. had this to say:

> "Questions have now been asked on two specific uses of thermoplastics as an indicator of thinking of the Laboratories' staff. One was whether slow-burning knobs would be acceptable on air-conditioning equipment where no other combustible materials were used in the interiors of the equipment. The answer was definitely that such knobs would be acceptable.
>
> "The other question was whether grills or decorative fronts of slow-burning material would be accepted in air-conditioning equipment where no other combustible materials were used on the interiors and away from the electrical system, so that any failures in that system would be unlikely to ignite the grills. The answer was that such grills would be acceptable. These slow-burning materials may be used under other conditions depending on the design of the equipment."

It should be recognized that, as a matter of policy, U. L. does not give blanket approval to materials. The design of each appliance submitted for approval must stand on its own merits.

CASE HISTORIES

Exclusive Sentri-Seals effectively seal out foreign materials at temps up to 225° F for extended periods — up to 350° F for shorter periods. Made of Buna-N, they are compatible with silicone, petroleum and diester lubricants.

Photo courtesy: Thor Power Tool Company

Bearings Seal Out Abrasives... Allow Cool Operation In 21,600 R.P.M. Grinder!

CUSTOMER PROBLEM:
Tool manufacturer requires bearing design that will seal 21,600 r.p.m. grinder from abrasives . . . yet heat must be minimized for operator comfort since tool is hand held.

SOLUTION:
N/D Sales Engineer recommended a group of four New Departure integrally enclosed bearings . . . some with Sentri-Seals. These precision ball bearings successfully shut out microscopic grinding abrasives. And, even with such positive sealing, the virtually friction-free New Departures help keep the temperature low enough for comfortable hand operation. They're sealed and lubricated for life . . . promising trouble-free ball bearing performance without the added burden of periodic maintenance.

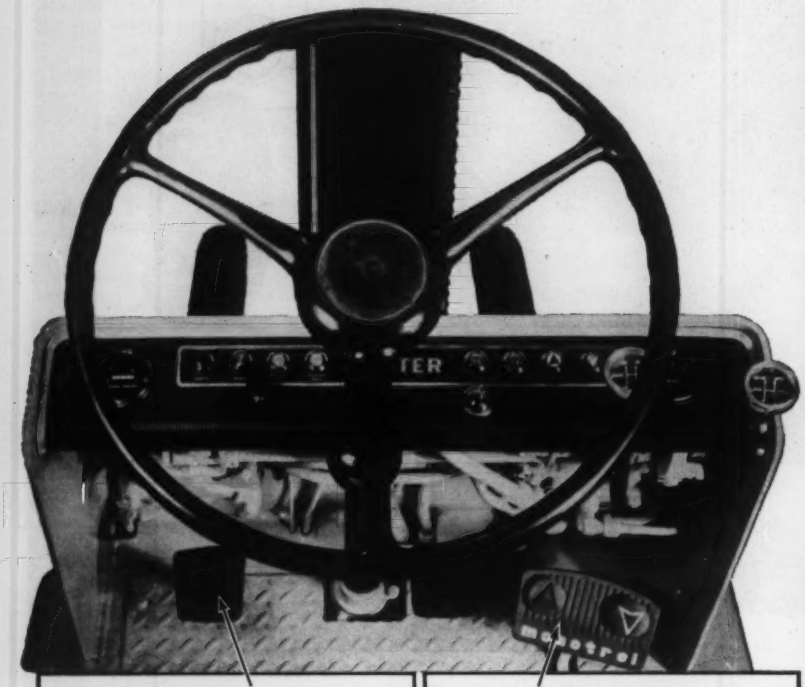
For immediate analysis of your current ball bearing problems, call the New Departure Sales Engineer in your area or write Dept. Q-5.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE
DIVISION OF GENERAL MOTORS, BRISTOL, CONN.
NOTHING ROLLS LIKE A BALL

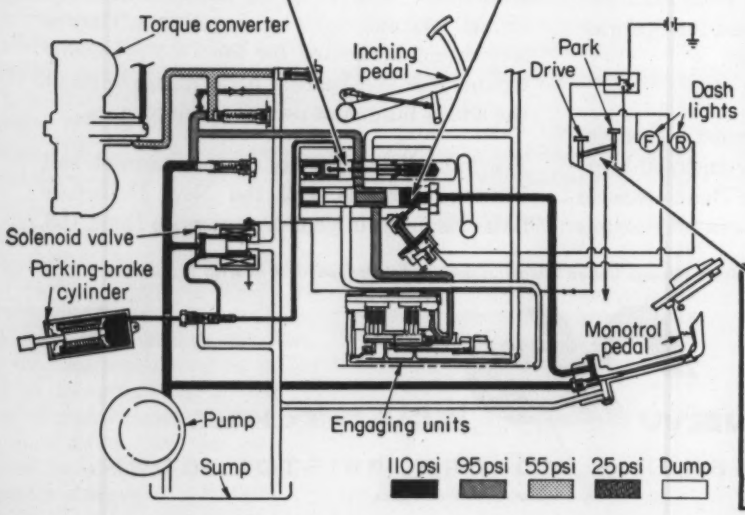
Operators control speed and direction with one pedal in Hyster's new Monotrol lift truck. It's done with a

Gas-Pedal Gear Shift



Partial depression of inching pedal by operator diverts transmission oil around inching-valve spool to drain. Transmission-clutch pressure is reduced in proportion to pedal stroke, giving close control of truck movements. Full stroke of pedal disengages transmission completely; bypass line from parking-brake valve opens to drain, and parking brake sets automatically.

Forward-reverse spool in Hystamatic transmission control valve is spring loaded to "reverse" position. Tipping Monotrol pedal to left sends high-pressure oil to pilot end of main spool, shifting transmission into "forward." Foot pressure on right side of pedal bleeds oil from pilot chamber to drain, and main spool moves right; transmission then shifts into "reverse."



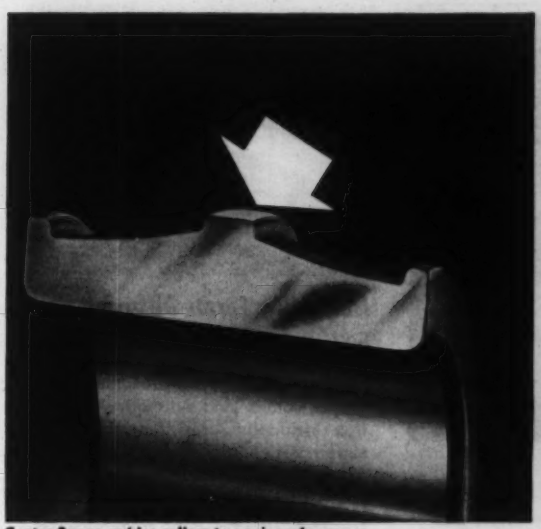
For fail-safe action, automatic parking brake is engaged at all times (spring-loaded "on") except when solenoid valve is energized. Pushing dashboard "Drive" button energizes solenoid, sends high-pressure oil to parking brake and releases brake. When "Park" button is depressed (or engine stops), transmission disengages and parking brake is applied. Engine can be started only when "Park" button is down.

SINGLE-PEDAL control of throttle and transmission is the latest human-factors advance pioneered on Hyster Co.'s line of lift trucks. Called Monotrol, the revolutionary new system eliminates hand-shift levers, frees the truck operator's hands for full-time steering and load-handling.

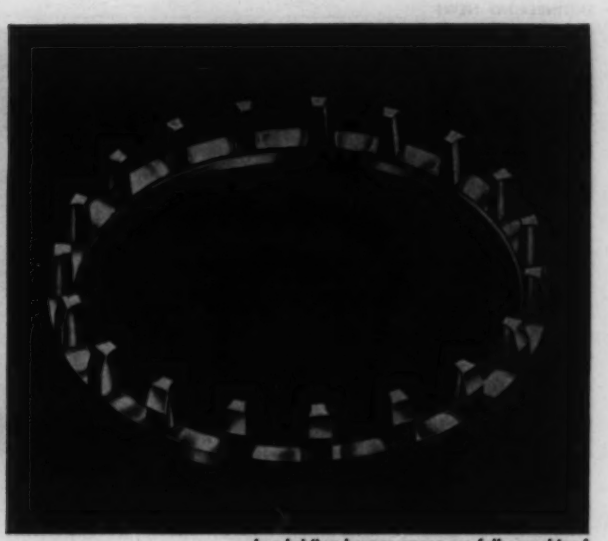
Key feature in Monotrol is an outsized pedal, linked to both the engine throttle and the Hystamatic power-shift transmission (MACHINE DESIGN, March 5, 1959, pp. 122-123). A touch of the operator's foot on the left side of the pedal shifts the transmission into "forward." Pressure on the right side of the pedal shifts the transmission into "reverse." Further depression of the pedal opens the throttle, gives the operator conventional control over engine truck speed.

Remaining controls governing truck motion are a conventional brake pedal (center pedal in photo), and a combination inching and brake pedal (left). By depressing the inching pedal with his left foot, the operator can exert precise control over truck movement while he keeps engine speed up with his right foot for fast load lifting. Depressed fully, the inching pedal disengages the transmission and applies the lift truck's service brakes.

According to Hyster, extensive proving ground and on-the-job tests of Monotrol have demonstrated big gains in safety, driver co-ordination, and tonnage rates. Initial installations will be on the 3000, 4000, and 5000-lb capacity lift-truck lines.



Center flange guides rollers to peak performance.



Land-riding bronze cages are fully machined.

Roller diameters are matched electronically within .0001".

Consider every design feature and you'll choose Torrington!

Torrington has compromised none of the operating design features of its Spherical Roller Bearing, because application experience has proved them essential to superior bearing performance.

There's no substitute for the stabilizing effect of the integral center guide flange. Torrington's asymmetrical roller seeks this flange under load. Skewing and stress concentrations are eliminated. Every roller carries its share of the load, for roller diameters are matched electronically within .0001" for even load distribution.

Rollers are precisely spaced by fully machined land-riding bronze cages that withstand even the high stresses of eccentric service. Two independent cages, one for each row, prevent roller drag and side stresses under thrust loads. Size-stabilized races prevent "growth" or change in dimension in service.

These features mean a cooler-running, longer-lasting bearing. When you buy bearings, look into *every* detail, and you'll choose Torrington. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

Superior performance features of TORRINGTON SPHERICAL ROLLER BEARINGS:

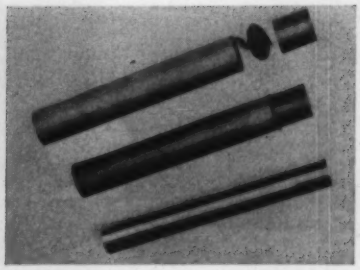
- Integral guide flange for roller stability
- Asymmetrical rollers seek flange for positive guidance
- Electronically matched rollers
- Size-stabilized races
- Fully machined land-riding bronze cages
- Controlled internal clearances
- Even load distribution
- Inherent self-alignment
- Long service life

Send for new Spherical Roller Bearing Catalog No. 258

SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST

Air Car Available in Limited Quantities

Ground-effect vehicle, developed by Curtiss-Wright Corp., will be available to "qualified" individuals, companies, universities, and governmental agencies for evaluation. The vehicle travels over land or water on a cushion of low-pressure air. Propulsion details of the prototype, above, were not released, although Curtiss-Wright officials say conventional piston engines ranging in size from 50 to 200 hp can be used in the system. The vehicle carries four passengers, travels in any direction at altitudes between 6 and 12 in.



New Alloy Forms Diffusion Bond

Carbide tool tips find new uses when applied with a new carbide-to-steel bonding alloy. Plymet, as the alloy is called, comes in a sintered wafer with flux included. After the wafer is inserted between carbide and steel surfaces, 500-psi pressure is applied and the joint is heated to 2000 F. Powder Alloys Corp., Clifton, N. J., says rapid diffusion of the interfaces, rather than melting, makes the bond. The resulting joint takes more than 100,000 psi breaking stress, is shock resistant, and can be heated well above the original bonding temperature.

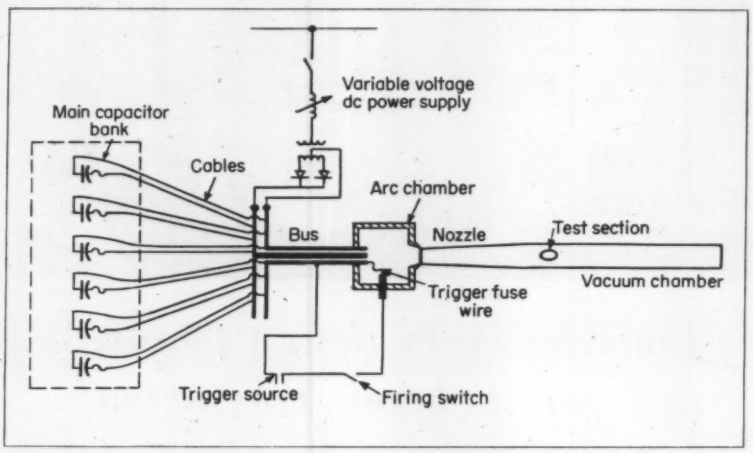
Five Million Amperes Generate Mach-27 Wind

Vaporized Piano Wire Triggers Man's Highest Current

SCHENECTADY, N. Y. — Hypersonic winds of 10 to 27 times the speed of sound will be "generated" electrically in a new wind tunnel. Designed by General Electric Co. for Boeing Airplane Co., Seattle, Wash., the million dollar wind tunnel is scheduled for completion by fall.

The electrical system will include a 42,900 cu ft energy storage bank containing more than 2000 capacitors with more than 200 acres of aluminum foil. The bank will store 7-million joules of energy and discharge it in a 5-million amp arc that will last a matter of milliseconds. The bank will be capable of being charged from specially designed rectifier equipment in about half a minute.

Peak current of 5-million amps is believed the highest ever created by man on a recurring basis. It is too high to be switched by any switching device now in use. Instead, the electrodes will be short circuited by a trigger arc created by vaporizing a small piano wire inside the arc chamber. Metal ions released by the vaporized wire will create a path for the main arc to "dump" the capacitor.



Vaporized fuse wire shorts electrodes in "hot shot" wind tunnel's pressure chamber, dumping capacitors' charge of 7 million watt-seconds in brief, million amp arc. After pressure buildup, diaphragm bursts, sending shock wave and hypersonic air flow past model in tunnel's test section.

In this "hot shot" wind tunnel, the high-energy arc will be discharged in a sealed chamber containing air compressed up to 2000 psi. The arc's energy, released almost instantaneously, will raise the compressed air to 18,000 F and 30,000 psi. At these conditions, air molecules are dissociated into separate, ionized atoms, possessing enormous kinetic energy.

The pressure will rupture a plastic diaphragm which will permit a high-energy shock wave to rush through the nozzle and test section of the tunnel. The shock wave will be followed by a hypersonic flow of air past the test model. Before each shot, the nozzle, test section, and exhaust chamber beyond will have been pumped out to high vacuum, further increasing the pressure differential that creates hypersonic flow.

Short-duration arcs are making

capacitor storage and discharge systems increasingly important in scientific research. Similar systems are used in studies of atomic fusion, where extremely high temperatures are required, and in ion propulsion, which may some day replace chemical fuels for rockets and space vehicles.

Industry Advises Civil Service How To Procure Engineers

Play Up Advantages, Revise Pay Structure

WASHINGTON — To attract first-rate scientists and engineers, premium features of Government scientific programs must be emphasized. At a recent Conference on Scientific Manpower, industry speakers advised Civil Service staffing officials to "play up" advantages of Federal employment.

Competition for top-quality scientific personnel will continue and will possibly be intensified in the future. While it is unlikely that Government pay can be made fully competitive with industry's, the gap can be offset by other attractions. Federal scientists already have many of the considerations they seek, but need to be made more aware of this fact. As examples, speakers pointed out opportunities to:

- Research on a wide variety of exciting and challenging programs.
- Engage in basic research without production-related pressures.
- Work in well-equipped facilities without worry about adequacy of research funds.
- Pioneer in new areas of technology.
- Participate in work vitally important to the national security.

Solution to the pay problem requires added flexibility in the Government's pay structure, not a separate pay system for scientists and engineers. Government service must be flexible enough to allow for advancement to top rungs for scientists who wish to stay in creative work rather than transfer to administrative duties. Government must recognize that scientists have different interests and motivations which require special consideration.

DRAFTING TRENDS

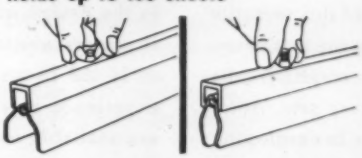
This Rolling Stand is one of many new Plan Hold units recently developed to make vertical filing more efficient.

New efficiency in vertical filing equipment

Vertical filing is a real space-saver, but home-made or "Rube Goldberg" systems have always created problems. Holes must be punched or drilled in blueprints and maps. Unsightly supports and devices must be built to hold groups of drawings and plans. None of these methods have ever been entirely satisfactory.

Now, with any one of the dozen modern Plan Hold Vertical Filing units, these problems can be eliminated.

Spring-actuated binder holds up to 100 sheets



The keystone of all Plan Hold units is the individual binder. It holds one to 100 prints safely and securely. The spring-actuated clamp is controlled by wing nuts to open and close the binder. The sheets hang wrinkle-free without curling. Binders are available for all popular sheet sizes.

Space-saving units provide maximum flexibility

The trend toward vertical filing is growing rapidly because of the flexibility offered. Plan Hold units can be installed anywhere . . . on the wall, at a table, in cabinets, closets, vaults or in rollaway units. Even hard-to-file items can be accommodated in special vertical pocket files.

The range of Plan Hold units that can handle various vertical filing situations includes space-saving wall racks, carousel-type units, rolling stands, swing-away racks and complete cabinets. They protect drawings, eliminate folding, rolling and stacking. And they provide an orderly, efficient system to accommodate and identify all large drawings.

For a complete 16 page catalog showing the full range of Plan Hold vertical filing equipment, write Frederick Post Company, 3652 N. Avondale, Chicago, Illinois.

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ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

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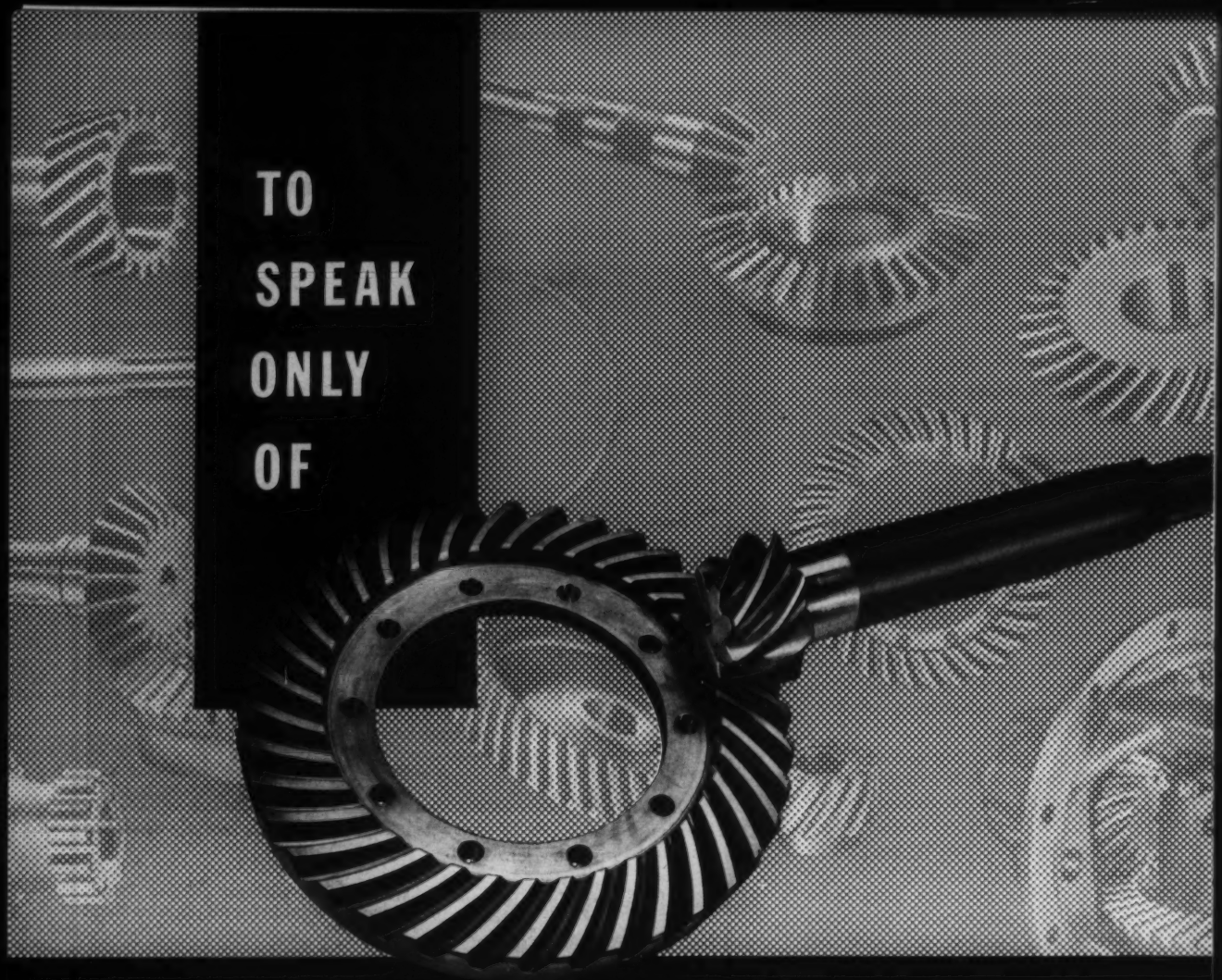

SPIRAL BEVEL GEARS

Spiral bevels comprise just one of the ten gear types in which we specialize, but, speaking of them alone, we have been active in their manufacture since their wide-spread acceptance around 1920. Thus, our experience covers the entire history of this versatile and useful gear type. We were among the first to use lapping on a production basis and to emphasize the importance of lapped and mated gear sets. Automotive Gear was one of the pioneers in developing and promoting the use of special fixtures to eliminate, as much as possible, the chance of human error, and in this way furthered the progress and practicality of spiral bevel installations. Engineering aid in the design of these fixtures for any application is always available to spiral bevel customers . . . as is aid in any area where our specialized gear experience may prove useful. Our gear engineers are available for consultation. Just write!

EATON

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MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
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408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
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419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
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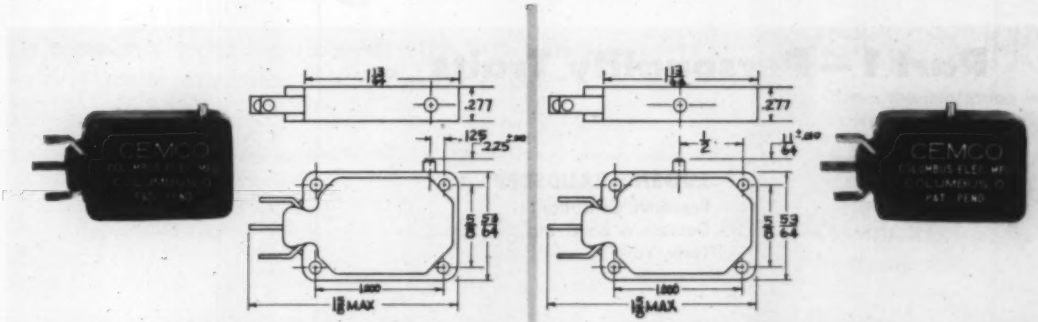
CEMCO

WRAP AROUND

A NEW SNAP SWITCH PRINCIPLE

(PATENT PENDING)

SPRING FORCES IN SYMMETRICAL BALANCE



JMP-100 COIN SWITCH					JMP-500 STANDARD SWITCH				
PRETRAVEL	DIFFERENTIAL	OVERTRAVEL	OPERATING FORCE	RELEASE FORCE	PRETRAVEL	DIFFERENTIAL	OVERTRAVEL	OPERATING FORCE	RELEASE FORCE
.050 Max.	.030 Max.	.050 Max.	27gm Max.	12gm Min.	1/32 Max.	Gap .010- .007 Movement Gap .020- .010 Movement Gap .030- .015 Movement	.025 Max.	20 oz. Max.	3 oz. Min.
CIRCUIT	CONTACT GAPS AVAILABLE	MECHANICAL LIFE	ELECTRICAL RATINGS		CIRCUIT	CONTACT GAPS AVAILABLE	MECHANICAL LIFE	ELECTRICAL RATINGS	
S.P.D.T.	.020	over 1,000,000	125 V.A.C.—5 Amp.		S.P.D.T.	.010 .020 .030	over 1,000,000	125 V.A.C.—12 Amp. 250 V.A.C.—6 Amp.	

1 The Cemco switch uses a new snap switch principle which has several important design features.

2 The spring members used have the lowest spring gradient consistent with the job to be done.

3 The spring blade carrying the moving contact, when in compression, has a slight sliding motion which gives contact-wiping action.

4 The motion of the moving members is designed to be linear. The mid-point of the actuating spring member (main blade) and the operating button travel in lines that are straight and parallel to each other.

5 The spring forces of the main blade are distributed between two legs, one on each side of the center blade, thus balancing out bending moments. These forces are in symmetrical balance.

THESE DESIGN FEATURES GIVE THE FOLLOWING ADVANTAGES:

1. Low gradient spring members give a lower movement differential for a given force, or a lower force differential for a given movement. **2.** Low gradient spring members, being thinner, give longer life. **3.** Linear motion of the moving members reduces the movement differential since "the shortest distance between two points is a straight line." **4.** Wiping action gives highest electrical capacity, particularly on inductive loads, since the wiping action of the moving contact breaks small electrical welds. **5.** "Repeatability" is better with this switch because there is only one mechanical joint. Mechanical joints, particularly when loose, are hard to control. Solid spring members, as long as they are operated within the limits of their elasticity, repeat many more times and much more accurately. Very small burrs in mechanical joints also tend to affect "repeatability" adversely. Applications have been made for patents covering this new switch principle. Your inquiry regarding its application to specific switch problems is solicited.

cemco

COLUMBUS ELECTRIC MFG. CO. 2005 E. MAIN, COL'S., O. CL 2-5551

Circle 413 on Page 19

Survey Uncovers 30 Attributes of

The Creative Engineer

Part 1—Personality Traits

EUGENE RAUDSEPP
Research Consultant
Deutsch & Shea Inc.
New York

MANY ATTRIBUTES identify the creative engineer and differentiate him from his less creative colleagues. Personality traits and intellectual abilities vary a great deal from man to man. Lack of familiarity with the mechanics of creativity has restricted the output of many a potential genius.

No individual can measure uniformly high on all of the characteristics of creativity. Some attributes are stronger in one creative person than in another. But the creative person must possess at least a minimum number of creative qualities or he cannot be creative.

Creative ability can be improved. By conscious cultivation of desirable attributes, an engineer can substantially increase his creative output.

In this series, 30 attributes of the creative engineer have been singled out from a mass of research data. Broadly speaking, eleven of these attributes can be classed as personality traits.

Self-Confidence . . .

It is seldom realized how large a dose of self-confidence and self-sufficiency a creative engineer requires. One of the most serious blocks that stifles, inhibits, and sometimes even nips a budding career is lack of confidence. By expressing itself in fear of criticism, in doubts of ability, in unfavorable comparison with past achievements, or in fear of appearing illogical, foolish or unusual, lack of self-confidence stifles and suppresses creativity.

Daringness to transcend the accepted patterns of thinking and to stick to convictions in the face of discouragement, disapproval or censure is an absolute necessity for any creative person. As Professor John E. Arnold of Stanford University says:

- *If, through continued application, failures can be corrected, high orders of self-confidence can be developed. Actually, the fear of making a mistake is a very devastating emotional block to creative activity. People should realize that progress is made through failure as well as through success.*

Motives Behind the Man

In a recent study by Deutsch & Shea Inc., here's how 105 top authorities ranked the motivations for creativity:

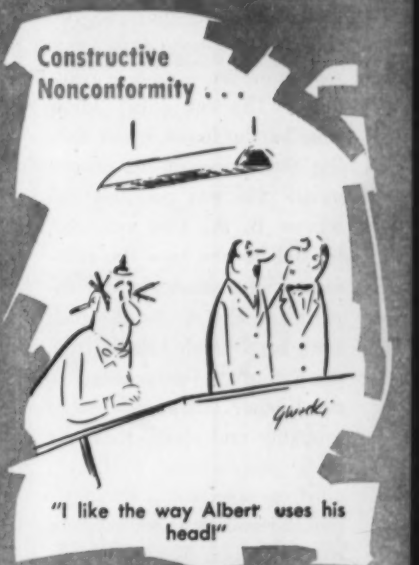
Desire to solve problems	68.6%
Personal gratification obtained by accomplishment	64.0
Desire to win scientific prestige	64.0
Desire to advance in financial position	42.0
Desire to advance in title	14.3

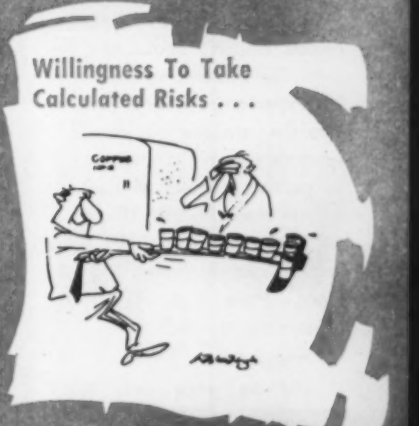
While "desire to advance in title" ranks relatively low, self-realization and growth are important motives to the creative engineer. He is, in an important sense, seeking self-fulfillment.

Why do some engineers frequently have "brainstorms" while others seldom even have "good ideas"?

To answer this question, the author has surveyed experts on creativity across the nation. Engineering and research managers, professors, philosophers, psychologists, social scientists, consultants—all working with creative people—have provided information. A supplementary source was a 105-man panel of experts (see "The Ideal Creative Supervisor," Sept. 18, Oct. 2 and 16, 1958).

This three-part series identifies—for the first time anywhere—thirty major attributes of the creative engineer.





Self-confidence cannot be built up alone. The young creative worker in particular needs early encouragement and recognition. He must develop confidence that eventually he will come through, no matter how many times he may fail.

Constructive Nonconformity . . .

Conformity has become the disease of our time. The pressure on the individual to conform to the group begins early and continues throughout his entire life.

The creative technical person is willing to be different. While he does not have the license to be rebelliously difficult to deal with, he can sweep the cultural, institutional and other barriers aside, and stand alone if need be. He is willing to fight for his inner integrity and for his right to fulfill and realize uniqueness and creative potential. As Professor Harold R. Buhl of Iowa State College has stated, "The individual, if he is to find new, creative answers, must be unconventional, must do things in ways not tried before. He must be a nonconformist, risking the criticism of others for not being average."

Professor Robert H. Knapp of Wesleyan University reports that creative individuals "don't like to be bossed around; they are sensitive about it. They are not tractable and flexible in organizations. . . . They tend to be self-sufficient." He further notes that creative individuals display "complexity of outlook and independence of judgment. Original persons prefer complexity and some degree of apparent imbalance in phenomena."

Professor Ross L. Mooney of Ohio State University sums up the creative nonconformist as a person who:

- Dares to be different in things that make a difference to him.
- Distrusts pat formulas for the control of his behavior.
- Dislikes doing the same things the same way all of the time.
- Feels something lacking in the average and ordinary situation.
- Wants to transcend the established order.
- Is aware that his own psychological independence and freedom is dependent on others having a

The Case of the Curious Cat

Legend tells the story about curiosity killing the cat, and the legend goes on further to show that the cat was very dead. Yet I like to think that the cat died not of curiosity, but of indiscretion. His curiosity to find out whether he actually did have nine lives is commendable; it was his scientific method that was at fault.

Everyone knows that nondestructive tests must be run before the destructive tests when only one sample is available. The cat didn't know this, but he found it out during the course of his experiment. He was probably the winner in the long run, too, for did he not have the satisfaction of a final glorious experiment, the results of which have been handed down from generation to generation in the legend? His experiment is probably understood today by more people than Millikan's oil drop experiment, Faraday's induced voltage experiment, or the Michelson-Morley experiment.

Of course, he had preconceived notions about the results; he guessed wrong. Yet his experiment was so conclusive that no one has found it necessary to repeat. Today it is partly because of the cat legend that the trait of curiosity is not honored. We have grossly misinterpreted this old story.—Prof. S. B. Hammond, *University of Utah*

similar psychological independence and freedom.

- Implicitly expects others to honor his own integrity.
- Will not let others run over him in the things of deepest value to him.

Willingness To Take Calculated Risks . . .

Willingness to take calculated risks is one of the more important traits of the creative engineer or scientist, and, as a matter of fact, of progressive management in industrial organizations. Here's what three authorities on creativity say:

- *Without this characteristic, we could never have progressed to our present standard of living. Suppose Ford had not been willing to gamble on the Model T or Kettering on the self-starter? Coming closer to our line of business, suppose Sarnoff had not been willing to gamble on TV or De Forest on the vacuum tube —where would the electronics industry be today? All creative work has an element of gambling in it along with the extreme faith of the individual that it is the right thing to do.*—C. M. Sinnett, RCA
- *The creative scientist is not only willing to take certain risks in his research plans, but must even to some extent enjoy or get satisfaction out of the risk-taking enterprise.*—Prof. David McLelland, Wesleyan University
- *The factual mind experiences few failures, the expansive (creative) mind many—but the creative mind always comes back for more. . . . The factual mind will be somewhat embarrassed by failures, the creative mind will be almost proud of them.*—Dr. Leopold Pessel, RCA

In the Deutsch & Shea study, *Company Climate and Creativity*, 72 per cent of the 105 authorities who participated felt that management attitudes of "can't afford to take chances" or "creativity — within limits" are the greatest stiflers of creative achievement in industry. Another 9.5 per cent felt these attitudes are at least equal to other inhibitive elements.

Openness to Experience . . .

One significant attribute of creativity is openness to experience. This attribute means that the creative person has a lack of rigidity of boundaries in concepts. It means a tolerance of ambiguity where ambiguity exists.

The creative engineer is continuously open to all the overwhelmingly complex and contradictory ramifications of experience. As expressed by Professor Carl Rogers of the University of Chicago who first discovered and explained the attribute, he has "the ability to receive much conflicting information without forcing closure upon the situation."

An additional refinement of the concept is offered by Professor Mooney:

- *The creative person seeks to extend his experiencing through holding himself open for increasing inclusions. This is evidenced by an inclination to take life as an adventure and a becoming, a curiosity and willingness to understand what is going on in oneself and in related aspects of the environment, a desire to get out to the edges of conscious realization and to feel a way into the unknown, an interest in new ideas and fresh perspectives, a spirit of play and experimentation.*

Openness to Feelings and the Unconscious . . .

The creative engineer is a more fully functioning individual than his less creative colleagues. He has more energy, is more impulsive, and is more responsive to emotions and feelings. He is able to bring a lot of buried material from the unconscious to conscious awareness.

The core of creative thinking lies deep within the unconscious. Lack of repressions and inhibitions eases the struggle through surface layers, and enables the creative engineer to have a more effective and uncluttered pipeline to the real source of ideas.

The really creative person is one who is not "afraid" of his unconscious. According to Professor A. H. Maslow of Brandeis University: "This is the person who can live with his unconscious; live with, let's say, his childishness, his fantasy, his imagination, his wish fulfillment, his femininity, his poetic quality, his crazy quality."

Since the creative engineer trusts his feelings, he utilizes them as guides during the creative process. According to Professor Mooney:

- *He trusts his feelings to guide him through an experience, sensing its form and flow.*
- *He moves toward solutions by progressively f e e l i n g his way through rather than forcing his way through.*
- *In judging the relevance of ideas, he seems to depend on a "feeling of fit," a sense of harmony, belongingness, appropriateness.*

Active Curiosity . . .

Creativity is, in an important sense, contingent upon the preservation of the innate curiosity and sense of wonder inherent in youth. Unfortunately, it is the one thing that is educated out of us, and is the attribute that is conspicuous with its absence in most grownups.

The creative technical man has retained his intense curiosity about everything. This interested, expectant and responsive attitude toward life keeps his mind well stocked with all kinds of information he can draw upon when creatively engaged. His active curiosity is not only content to see how something works. It constantly delves into the "reasons why" of devices and phenomena, with an interest in improving upon existing devices. The really creative individual is not only curious about the problems in his own field. His wide spectrum of interest embraces many fields and areas and he feels enthusiasm toward almost any problem that puzzles him, or appears in any way mysterious.

Professor Mooney summed up this attribute by saying: "He is more impressed with what he doesn't know than what he does know."

Sensitivity to Problems . . .

The philosopher John Dewey defined science as beginning not with facts nor with theories or hypotheses, but with the problematic situation.

One of the most important attributes of the creative technical man is his unusual capacity for seeing the need areas, for noting the "gaps" in products and processes, and for being able to note significant situations.

The creative engineer is constantly either seeking or finding challenging problems, whether they concern his work or his hobbies, or his home. He is perpetually disturbed by something. For him there is hardly a situation free of problems, and this "happy state of dissatisfaction" keeps his ever-present problem orientation alive.

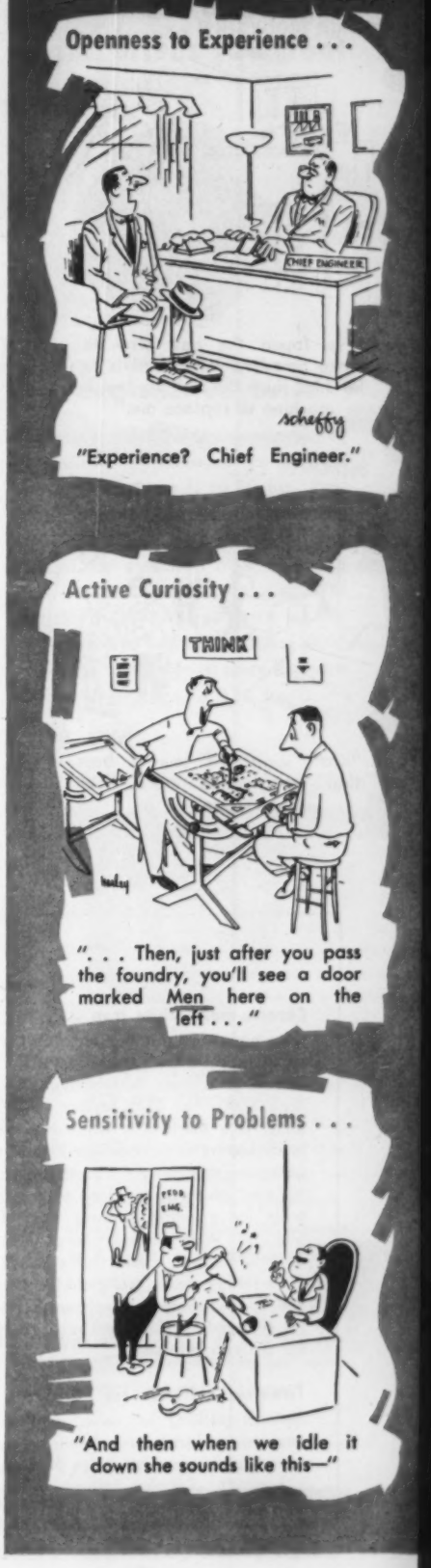
Constructive Skepticism . . .

The creative engineer is noted for his dissatisfaction with things as they are. He uses a questioning approach to almost everything he encounters, and he refuses to lapse into passive acceptance of the status quo. He constantly looks into chance findings, comments and suggestions for potential problems.

According to A. L. Simberg of General Motors: "The creative person is dissatisfied first. He feels that he must question everything that he perceives." In addition, C. F. Hix Jr. of General Electric says: "One must have the inherent desire to improve or develop those things with which he comes in contact. This seems to be a matter of temperament. It is often necessary to project this ability five to ten years ahead to suggest future problems and propose solutions."

High Motivation . . .

Basic to creative performance is a strong desire to create. The creative engineer has such a desire and is keenly interested in the area of his work and the things he works with. There are areas in his work that evoke his spontaneous enthusiasm, almost a passionate concern for the problems involved and an urge to grapple with them. He likes to, primarily, deal with things in-


Openness to Experience . . .
CHIEF ENGINEER
scheffy 60
"Experience? Chief Engineer."
Active Curiosity . . .
THINK
". . . Then, just after you pass the foundry, you'll see a door marked Men here on the left . . ."
Sensitivity to Problems . . .
"And then when we idle it down she sounds like this—"

High Motivation . . .
"I've found the best way to make Smedley work hard is to let him think he's designing a machine to replace me."
Initiative . . .
"Kraft suggested to the boss that we needed more floor space!"

trinsically highly interesting to him, and he is greatly stimulated by his own ideas and feelings. This means that he is governed by inner stimulus rather than by outer demand.

This is why the creative person, as Professor Mooney explains it, "is concerned with discovering the work which is most natural for him to do, most inclusive and challenging to all his capacities. He takes his chosen work as a primary and necessary means of fulfilling his life."

Initiative . . .

When a problem has been defined or a difficulty encountered, the creative engineer usually proceeds to solve it without further ado.

In the industrial context, the system of rewards tends to either greatly encourage or to discourage initiative. Dr. Morris I. Stein of the University of Chicago reports essentially two kinds of companies: Those that reward a creative idea as such; and those that reward only ideas which are considered as immediate money - makers. "Oddly enough," says Dr. Stein, "this limitation inhibits the production of all ideas—including those that make money. In general, it can be said, however, that in an environment where creative work is recognized as very important, initiative is high."

Capacity to Receive Criticism . . .

The creative engineer has developed an unemotional, impersonal, and objective attitude toward criticism, and he has learned, as Randolph W. Chaffee, a consulting engineer, has pointed out, "to ignore that which is unfounded and to profit from that which is useful." According to Simberg, "he is uninhibited about communicating his ideas to others regardless of how impractical they may appear. He is not afraid to think unconventionally nor to discuss the result."

When criticism is tendered, he shows tolerance and understanding toward it, and he studies the objections to his idea or device dispassionately. If then, after keen analysis and judgment of the objections, he is still convinced that his ideas or device is as worthwhile and good as he can make it, he is ready to present it. He forestalls the chances of a rebuff by putting as much development into his presentation as he did when he developed the idea.

Second article in this series, in the June 11 issue of MACHINE DESIGN, will deal with intellectual abilities of the creative engineer.

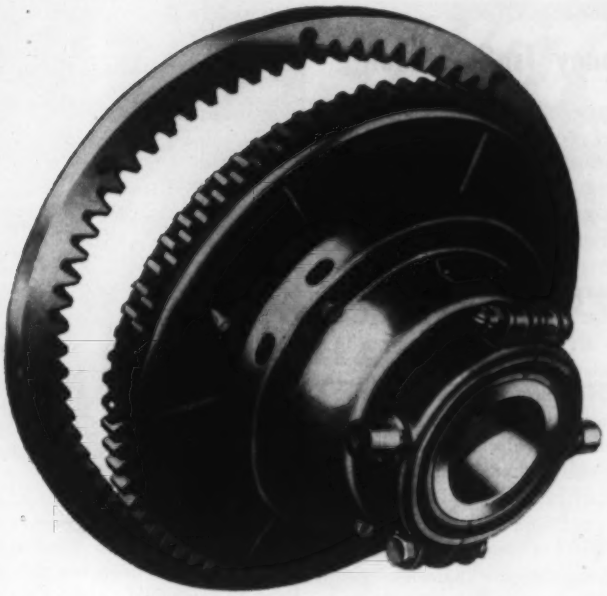
Metals Matters

Chrome-moly white iron . . . takes high-stress grinding abrasion better than pearlitic white iron, says D. V. Doane of Climax Molybdenum Co., New York. The alloy, known as 15-3 alloy, is a martensitic white iron already known for its resistance to erosive abrasion (scratching). The newly announced property will lead to use in mills for grinding abrasive minerals and ores. With the wear rate of pearlitic white iron as a base, chill-cast balls of 15-3 alloy used to wet-grind hematite and quartz showed wear rates of 34 per cent and 55-57 per cent respectively for the two substances.

Titanium bellows seal . . . replaces packing in valve stem assemblies produced for a homogeneous reactor project at Oak Ridge National Laboratory. Seamless bellows are believed by developer, Robertshaw-Fulton Controls Co., Richmond, Va., to be the first ever made from titanium. Gold-plated bellows were previously found unsatisfactory. The valves are used in a primary reactor loop carrying highly corrosive uranyl sulphate solution at high temperature and pressure.

Gold plating is in orbit . . . with three improved electroplating processes announced. 24 K gold-plate with hardness built-in by preferred orientation of the crystal lattice is offered by Technic Inc., Providence, R. I. Patents have also been issued to Lea-Ronal Inc., Jamaica, N. Y., for a process that plates gold with hardness 2 to 3 times that of plate from bright cyanide gold solution. Color of Lea-Ronal plate can be controlled from rich yellow to pale "Hamilton" for decorative plating. Bart Manufacturing Corp., Belleville, N. J., deposits an 18-K gold plate with a hardness of 300 to 450 VHN. It is used on slip rings, contacts, and brushes where surface pickup and wear are critical. In the decorative field, it offers superior resistance to wear, better color, and elimination of need for Hamilton Flash.

Atomic fuel problem . . . has been solved by soldering uranium to aluminum with 70 per cent zinc solder. It was found to give the strongest bond of all solders tested. Choice of materials was limited to those with low thermal neutron absorbtion cross section and good corrosion resistance in boiling distilled water. Addition of tin to solder was found by Battelle Memorial Institute, Columbus, Ohio, to increase corrosion resistance. Highest strength and corrosion resistance comes from 70 per cent tin; 30 zinc.



Twin Disc CL Heavy-Duty Clutch —

the clutch with the built-in safety factor

Throughout the world design engineers have come to rely on Twin Disc Model CL Clutches for economical, trouble-free performance in a wide range of power train applications. Model CL's reputation for durability in severe service is due in large part to conservative work capacity ratings. There are ten standard CL sizes (5½" to 11½") for transmitting loads from 1.9 to 19.3 hp per 100 rpm; all are rated with an ample safety factor to take shock loads without distress.

All surfaces are of high strength cast iron, yet overall dimensions are held to a minimum to save space in machine installations. Cover enclosure permits operation in the open without housings or guards. Adjustments are made from the outside — no tools necessary.

Model CL is available with one, two or three drive plates. Where the clutch is engaged frequently, the single-plate design is recommended. Two- and three-plate clutches double and triple torque capacity within the same diameter. Choice of standard gear tooth driving ring or driving spider assembly. Throw-out yoke, hand lever and operating shaft optional.

Specify CL Clutches for easier control, longer wear life, less maintenance. Remember, too, that Twin Disc Clutches are backed by an unparalleled parts and service program.

TWIN DISC

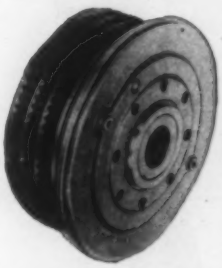
TWIN DISC

Friction Clutches and Fluid Drives

Immediate delivery on the drives you want

Twin Disc HYDRO-SHEAVE® Drive

A complete fluid drive package for immediate application to motors and engines from ¾ to 50 hp. Provides smooth operation, prevents stalls and shock load damage, permits motor selection on a running load basis. Designed for use with standard QD sheave, can be installed in five minutes. Other fluid couplings available in sizes through 27" for capacities to 850 hp.



Twin Disc PO Air Clutches

Similar to CL Clutches except for air-actuation feature. Designed for remote control without complex linkages where compressed air source of 60 to 130 psi is available. Self-compensating for wear — never need adjusting. Cartridge-type diaphragm positively prevents air leakage. Sizes from 8" to 36" with one, two or three drive plates.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND • DALLAS • LOS ANGELES • NEWARK • NEW ORLEANS

Engineering Enrollment Drops; Money Isn't Reason

Nationwide Trend Continues Despite Impending Shortage

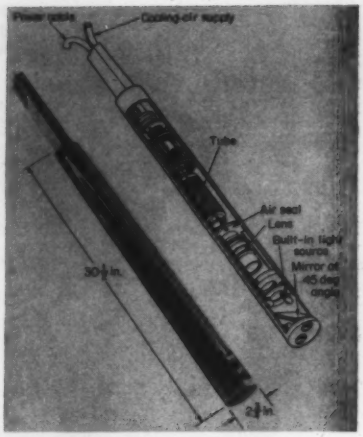
ITHACA, N. Y.—Demand for engineers is increasing, and starting salaries continue to rise, but the U. S. will have fewer engineers in five years than it does now.

Backing up this statement, Donald Moyer, director of student personnel at Cornell University's College of Engineering, says fewer beginning college students are entering the field than at any time in the recent past. In the fall of 1957, for example, 635 freshmen entered Cornell's College of Engineering. In the fall of 1958 the number had dropped to 547, and estimates for next year place the figure at 450 to 500. "This reflects a general trend throughout the country," Mr. Moyer says.

"During the 1958 recession, the demand for engineers dropped sharply, causing many persons to think the engineering shortage was over," Moyer explains. "Also, Sputnik created a shift in emphasis from engineering to science. Engineers may have gotten the satellite off the ground, but most of the publicity was given to the role of the scientists who created it." Consequently, need for engineers has been obscured by an apparent greater need for physicists and chemists.

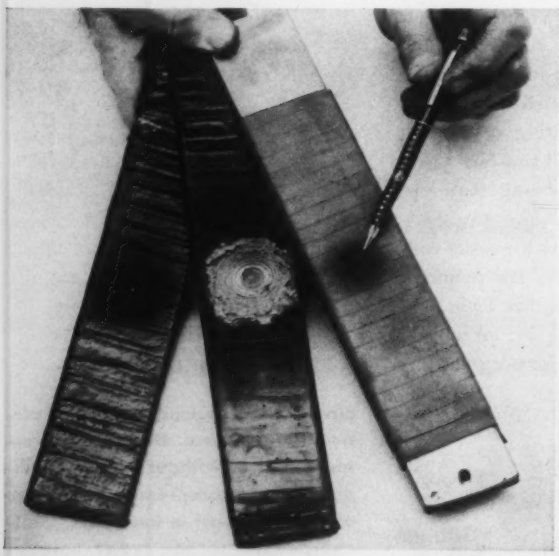
Mr. Moyer foresees greatly intensified competition for engineers by 1964, with their already-high salaries going still higher. "In five years, the median salary for Cornell's graduate engineers will probably be at least $700 a month to start," Mr. Moyer states. "Salaries for Ph.D's, of course, will be considerably higher."

Median salaries for graduates of Cornell's five-year engineering program are now between $530 and $550 a month.



TV for Tight Quarters

Atomic reactor tubes in Canada's Chalk River installation are inspected for flaws with this beanpole-shaped TV camera. Diamond Power Specialty Corp., Lancaster, Ohio, designed special focusing and deflection windings around a standard vidicon tube to produce a 2¾ in. diam package. Built-in light source and periscope-like mirror allow clear view of interior walls.



Motor Insulation Gets Boost in Mechanical Strength

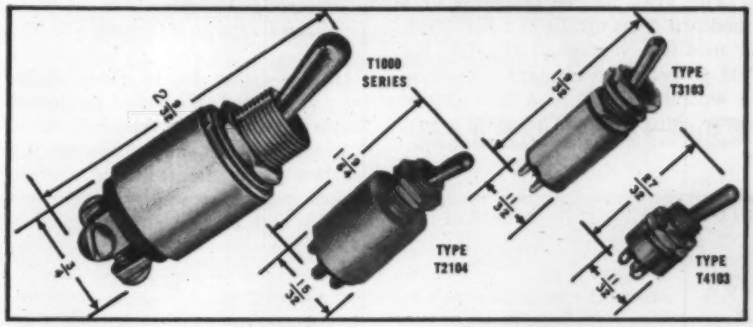
Tough new insulation for electric motors consists of Dacron and glass tape impregnated with silicone rubber. The new material retains silicone rubber's excellent dielectric and sealing properties while adding mechanical strength previously lacking in silicone insulations. Developed by General Electric, and called Polyseal, the resilient material will be used on all GE form-wound motors and on 1 to 125-hp random-wound motors. One big advantage of Polyseal—it permits use of drip-proof motors in many applications that formerly required totally enclosed motors. Its high resistance to abrasives, for example, is shown at left. Coarse grit sprayed under pressure against two conventional insulations cut through to the metal, while Polyseal withstood the test. As insulation for random-wound motors, right, Polyseal gives positive protection against moisture and contaminants. Since a thin coating is adequate, heat transfer is good. Flexibility and bonding properties are unaffected by temperatures of −40 to 200C.

HETHERINGTON

SWITCHES • INDICATOR LIGHTS • SPECIAL ASSEMBLIES

ENGINEERING NEWS

Say "WHEN" to Toggle SWITCH MINIATURIZATION



Few basic electrical components have been successfully miniaturized with such telling effect as the toggle switch. Hetherington has developed space- and weight-saving cylindrical types with ratings, dimensions, and performance tailored to the critical requirements of airborne and industrial electrical systems. And, thanks to Hetherington's positive cam-roller snap action, even the smallest types carry ratings far greater than their sizes would indicate.

Recent Hetherington developments such as the sub-miniature Type T4103 shown above approach the point where further miniaturization would seem to present more difficulties in mounting than in obtaining adequate switch performance. Although not quite ready for production, field tests of the T4103 have shown great promise for drastically cutting weight while assuring better performance in aviation's toughest jobs.

Circle 415 on Page 19

"BILLBOARD" LIGHTS

Make Crowded Panels More Meaningful

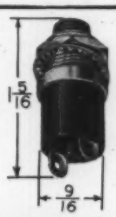
Too often the significance of tiny conventional indicator lights is hard to determine at first glance—especially if many are used on one panel. With Hetherington Placard Lights, vital control information can be read directly in terms of symbols, digits, abbreviations, words, or entire phrases engraved on plastic lenses. Two miniature AN3140 lamps boldly illuminate the lettering, thus avoiding delay or errors of interpretation.

In spite of their large (1-3/8" x 9/16") lenses, over 40 Placard Lights fit comfortably in a 9 x 5" area thus simplifying many annunciator-type panels where lights are closely grouped. For details, write for Data Sheet L-3.

Circle 416 on Page 19

8 AMP U. L. RATING

... ½ amp Size and Price



Here's just the push-button switch to dress-up and improve that instrument, appliance or other "black box" now on the drawing table—and with attractive cost and space advantages in the bargain.

For the performance of these B-Series Switches comes mighty close to that of Hetherington's aviation-quality switches in terms of positive "feel," fast and audible snap-action. Normally-open or closed SP-ST types with 8-amp U.L. Approved ratings available with lugs or 6" leads. Send for Data Sheet S-4.

Circle 417 on Page 19

SWITCH PROTECTION "TAILORED"

to humidity ... moisture ... spray ... immersion

Although the mechanism of every Hetherington push-button and toggle switch is protected by the case against dust and moisture, some special requirements call for additional "climate-proofing." Where the perfect hermetic seal of a metal bellows is not needed, "O" rings, sleeves or boots of lightweight silicone rubber offer inexpensive solutions for most applications as shown by the typical types at right.

"O" RING AT BASE OF LENS ON INDICATOR LIGHT
RUBBER BOOT MOLDED TO HEX NUT—TOGGLE SWITCH
RUBBER BOOT MOLDED TO HEX NUT—PUSH BUTTON SWITCH
METAL BELLOWS HERMETICALLY SEALED TO SWITCH CASE
INTERNAL RUBBER SLEEVE AROUND BUTTON

HETHERINGTON INC. Delmar Drive, Folcroft, Pa. • 139 Illinois St., El Segundo, Calif.

standard switches for the most specialized requirements

A Controls Company of America Subsidiary

Man-Carrying Rocket Ordered for '61

Interplanetary Career Planned for Vega

WASHINGTON—Eight Vega rockets will be available for manned flight to neighboring planets sometime in 1961. The NASA has awarded a "develop and deliver" contract to Convair Div., General Dynamics Corp., San Diego, Calif.

While a single two-stage model of the new space vehicles probably will be used for lofting several scientists and a two-ton space laboratory into a 300-mile earth orbit, the three-stage model is more intriguing: Weighing almost 150 tons and standing as high as a ten-story office building, the three-stage rocket will put man in space. This version of Vega will be able to send a 1000-lb payload to the vicinity of the moon and land several hundred pounds of instruments on the moon's surface. It will also be able to power a 750-lb payload on a planetary mission.

The Vega will be propelled by a modified Atlas missile as a first stage, a modified version of the GE liquid-propellant Vanguard booster as a second stage, and a new engine as a third stage. The third stage, which will use nitrogen tetroxide and hydrazine as storable fuels, will be developed by NASA's Jet Propulsion Laboratory, Pasadena, Calif. JPL will have technical supervision over the Vega Project and will plan planetary payloads.

Silicon Lenses Show New Growth

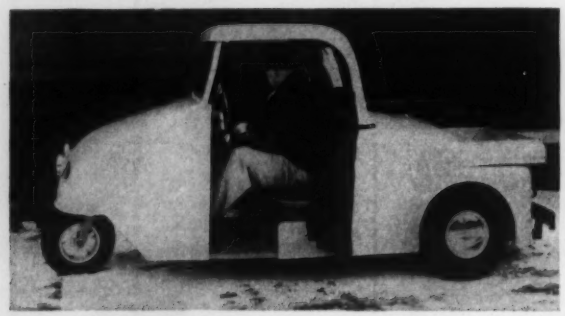
Individual silicon lenses grown to 10 in. diam and silicon domes grown to 8 in. diam are available in production quantities from Knapic Electro-Physics Inc., Palo Alto, Calif. Principal use is in lenses for infrared sensing devices. Coated silicon lenses pass 92-97 per cent of the infrared band between 1 and 8.5 mu. Visible light is blocked. Silicon lenses are essential components in military infrared devices such as cameras, homing missiles, and early warning devices. Detecting power is related to the square of lens diameter. Previously available material has not been larger than 5 in. diam.

Flying Glass Beads Improve Strength and Finish of Metals

Process Is Harmless For Sharp Edges and Threads

DALLAS—Glass beads electrostatically suspended in a liquid are found superior to shot for peening metal surfaces. Beads, blown against the surface being treated, seal surface pores, smooth rough surfaces, but do not nick or injure the basic metal. Even sharply machined edges and threads are free from nicks after treatment. Scale, corrosion, burrs, and tool marks are removed leaving a surface roughness of only 4 mu in. Developer, Aero-Test Equipment Co., reports an amazing increase in fatigue life due to surface work.

The capacity of glass to deform elastically allows the beads to follow sharp changes in contour while still retaining energy for working the surface. Beads shatter from overstress before sharp edges are damaged. Particles are not imbedded in the material being peened, nor is the basic metal removed or altered in dimension.



"Sound Truck" Tests Freight-Car Axles

Six crystals in the gun-like probe send out angled ultrasonic beams for checking freight-car axles. Bouncing from side to side in the axle, waves form a pattern that is reflected back to the probe. Any variation in the expected pattern of response means a flaw or crack in the axle and triggers a warning light in the probe handle. Battery and transistorized power supply are carried in the 1300-lb three wheeler with a glass-fiber body. Sperry Products Inc., Danbury, Conn., says over 600 freight-car axles can be inspected per day with the new unit.

Allis-Chalmers tackled this motor problem "cold"

Even heavy icing couldn't freeze this motor. An Allis-Chalmers customer required that this open-type *Super-Seal* motor start even though embedded in ice.

Successful tests were conducted in the A-C Motor Laboratories where customers' motor needs point the way to continuous development programs.

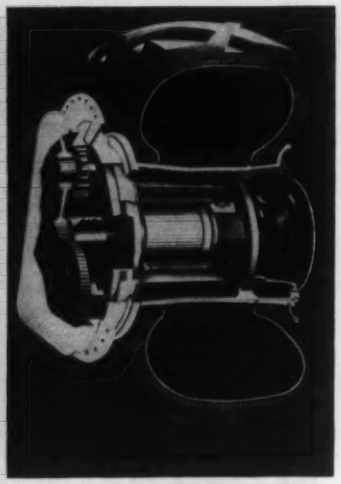
Research and testing of this type has established Allis-Chalmers as a pioneer-leader in the motor industry. It has led to the most complete line of integral-horsepower motors; it has led to tremendous acceptance of such A-C developments as *Synduction* and tube-type motors, and now *Super-Seal* motors.

You can benefit from this pioneer-leadership by contacting your A-C representative or distributor, or by writing Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

Super-Seal and *Synduction* are Allis-Chalmers trademarks.

Circle 418 on Page 19

ALLIS-CHALMERS A-5956-G1



New Electric Wheel Puts Motor in the Hub

Fundamental design change in motorized wheels—mounting the traction motor inside the wheel hub—gives the designer of big earthmoving equipment more room to work. Developed by General Electric, the new wheel centers a conventional dc series-wound traction motor in a 45-in. rim. The motor provides 380 rim horsepower, and four of the wheels will propel a 125-ton vehicle 35 mph. The system provides dynamic braking capacity approaching three times the available traction horsepower over most of the speed range. During braking, wheel motors serve as generators and dissipate the vehicle's kinetic energy as heat in air-blown resistors. There are no wearing parts and no brake fade.

High-Frequency Fluorescence Field-Tested for Bus Lighting

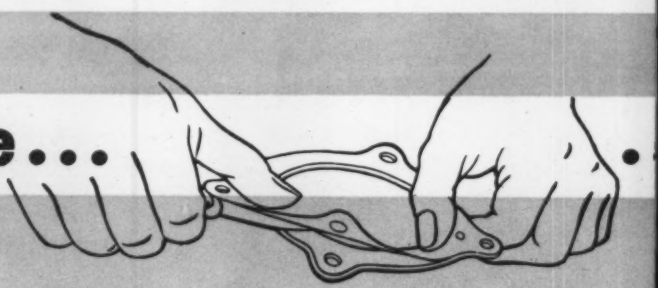
Inverter Power Supply Saves Space, Weight, Money

CLEVELAND — A new fluorescent lighting system is giving riders of one bus enough light to read their papers. Developed by General Electric Co., it is now installed on a Cleveland Transit System bus for field evaluation.

A transistorized electric inverter is the basic new power supply that makes the system practical. The inverter, made possible by recent advances in power transistors, converts the bus battery's 12 v dc to 400 v, 3000 cycle power.

Previous fluorescent lighting systems for transit equipment have been less satisfactory due to low power frequencies used. High-frequency equipment has been too heavy and too big for transportation uses. The best fluorescent lighting power supply for buses has, up to now, been a variable-frequency alternator system operating from the

Our Superiority Here...



LAMINUM®
the solid Shim that p-e-e-l-s for adjustment

Our superiority in the production of Laminated Shims of LAMINUM, to the most exacting specifications, results in numerous and profitable advantages. Manufacturers of aircraft, missiles and rockets, of motors and engines, of machine tools and similar precision-assembled equipment save time, cut costs and turn out better products with LAMINUM. Close-tolerance accuracy in fit and alignment is assured...with never a need for grinding, counting, stacking nor miking. Laminated Shims of LAMINUM simply p-e-e-l for adjustment, with no dirt between layers—ever!

Brass with laminations of .002" or .003"

Mild Steel with laminations of .002" or .003"

Stainless Steel with laminations of .002" or .003"

Aluminum with laminations of .003" and NEW .002"

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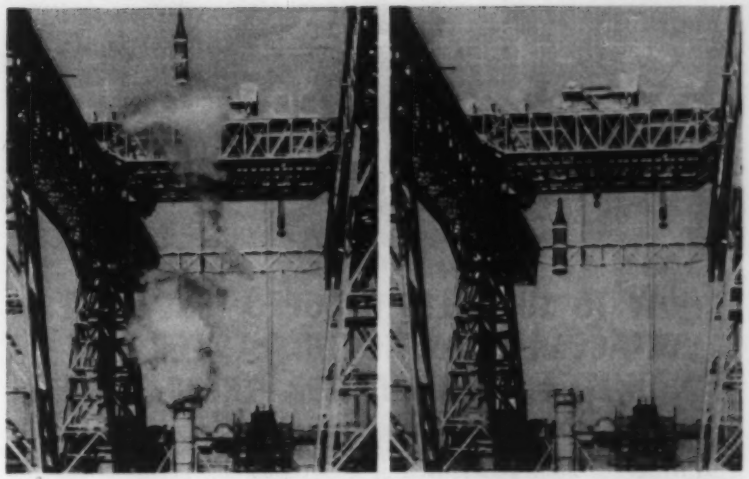
Circle 419 on Page 19

bus generator. It provided power at 100 to 500 cycles. The new high-frequency system increases efficiency of the alternator system an average of 70 per cent.

The bus lighting application requires a single inverter, 16 fluorescent lamps, each housed in a one lamp fixture, and eight ballasts. Weight of inverter and ballasts is only 26 lb.

Money savings are realized through the inherently higher efficiency of high-frequency fluorescent lighting. The 16 lamps produce three to nine times the illumination of former filament units and consume only ¾ of the power. Efficiency expressed in light per dollar terms is nearly four times that of the filament lamp system, says V. C. Kauffman, engineering manager of GE's Large Lamp Dept.

The new system should clear the way for the transportation industry to make wide use of high-frequency lighting. Benefits of high lighting levels at low cost have previously been enjoyed mainly by industries, office buildings, etc.



Mid-air Missile Catcher Beats Retrieval Problems

Stopped at the top of its launch trajectory, a dummy Polaris missile is lowered gently to the ground by restraining cables—the latest technique in development of the undersea missile's launching gear. Intact recovery of the vehicle and its delicate payload of instruments not only simplifies retrieval, but permits accurate study of stresses imposed on the airframe during launch. Previous Polaris tests used full-scale redwood dummies or metal airframes filled with concrete. Missiles were impacted in San Francisco Bay. The more sophisticated method, developed by Navy's Philadelphia Engineering Facility and Lockheed Aircraft, uses real Polaris airframes restrained by a modified carrier-aircraft arresting gear.

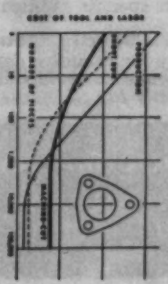
..Guarantees Superiority Here...

Actually, our famous Shims of LAMINUM are perfect precision STAMPINGS. Consequently, we have perfected our own special equipment and tooling, our own skills and techniques, unknown to ordinary stampings producers. Result: the unique ability to quickly produce precision STAMPINGS...in any contour, in any size...in any quantity "one to a million"...at the lowest possible unit cost. We have 3 exclusive Methods—pick the one that fits *you* best...

1. FOR A FEW PIECES
at Experimental or Pilot Stage
—we use our MACHINE CUT METHOD. No dies needed. Our special equipment, plus our unique techniques, are applied to produce small quantities at very low cost.

2. FOR SHORT RUNS
—we use our *low-cost*, SHORT RUN TOOLING METHOD. Our low cost tooling and simple dies, plus special presses, go to work to produce something more than "just a few." Quality is high—costs stay low.

3. FOR PRODUCTION RUNS
—we use our PRODUCTION RUN METHOD. Here is where our production tooling applies to great advantage, and when dies are needed, charges are moderate. The chart tells the story...top quality stampings at lowest possible unit cost.



Circle 420 on Page 19

ANY ONE OF THESE 3 METHODS WILL PRODUCE
AIRCRAFT-QUALITY STAMPINGS TO YOUR OWN RIGID STANDARDS

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Stearns Tech-notes on electro-magnetic BRAKES CLUTCHES

(choice of the leading motor manufacturers)

(Fourth of a Series)

HOW TO SUPPRESS INDUCED DISCHARGE VOLTAGE IN MAGNETIC CLUTCHES FOR LASTING *Matched-to-the-Machine* PERFORMANCE

Stearns engineers have proved over a forty-year period that careful attention to *ALL* details of an application can insure dependable, trouble-free installations. One of these important details is the suppression of discharge voltage . . . a factor that can minimize arcing, burned contacts, slow release time, costly maintenance and machine downtime.

The magnitude of electrical inductance inherent in electric clutches depends on the following factors: 1. Number of turns of wire in the clutch coil. 2. Nature of the magnetic circuit. 3. Air gap through which it operates. A discharge potential of several thousand volts can be induced across clutch coil terminals due to collapse of the magnetic field through coil windings, initiated by rapid opening of the electrical clutch circuit. This voltage surge travels along clutch leads to contacts of the switching device — where a considerable arc can occur. With clutches drawing 150 watts or more, used in humid atmospheres, protection of clutch leads against these voltage surges is advised. Four of the various successful methods used by Stearns engineers to suppress discharge voltage in specific cases are presented below:

METHOD I

A parallel-connected resistor of approximately the same ohmic value as that of the clutch suppresses discharge voltage very well, but has the disadvantage of drawing additional current from the line when clutch is energized.

METHOD II

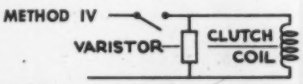
A parallel-connected blocking rectifier — with due consideration for proper polarity — will not pass input current, but provides a low impedance path to limit discharge voltage.

NOTE: Methods I and II, above, suppress discharge voltage quite well, but have a tendency to slightly retard release time. Methods III and IV, below, permit faster release.

METHOD III

Two parallel-connected, back-to-back rectifiers. One acts as a blocking rectifier, the other takes advantage of the non-linear voltage-resistance relationship of the selenium rectifier to limit discharge voltage.

METHOD IV



A parallel-connected varistor . . . a unit that has very high resistance at low potential, but becomes a conductor when potential exceeds a specified voltage. Provides fast release, but permits discharge potentials as high as 1,000 volts.

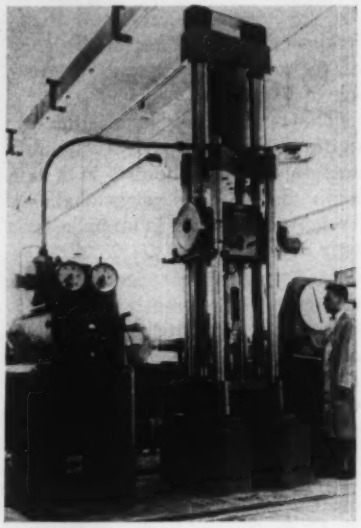
NOTE: Method III has been applied primarily to smaller clutches to eliminate arcing at switch contacts. Stearns engineers recommend careful analysis of each application to determine which method of suppression is best suited to application requirements.

Bring your starting-stopping problems to Stearns with complete confidence that whatever the requirement, a practical solution — unmatched for performance and installation-operating economies — will result. Stearns has standard clutches and brakes — ranging from miniature to "king-size" — available for prompt shipment . . . or will custom design and build units for your specific application.

For Superior Service — Performance . . . Specify Stearns!

Call the Stearns Representative in your vicinity for complete data on electro-magnetic clutches, brakes, and clutch-brake combinations. Or write, outlining your specific requirements directly to . . .

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN



Bolt Jolter

Repetitive fatigue loads of 250,000 psi are exerted 500 times per min by this big bolt tester at Standard Pressed Steel Co., Jenkintown, Pa. The machine can also perform static tensile tests to its full capacity. It makes available, for the first time, certified fatigue test data on all standard sizes of high-strength aircraft and industrial bolts—including 260,000-psi fasteners. In the picture, the tensile test station is at the right of the loading tower; fatigue test station is at left.

Convair-Run Lab Monitors Missile-Industry Standards

Instruments Half Bad; NavOrd Takes Corrective Steps

POMONA, CALIF.—Slight initial errors in missile trajectories result in critical errors on long flights. One reason for a missile's failure to follow its predicted flight path has to do with intercompany yardsticks.

To assure that each company supplying "missile hardware" is using the same standards, the Navy's Bureau of Ordnance commissioned Convair Div., General Dynamics Corp., to set up a standardization laboratory. This laboratory, the Western Primary Standards Laboratory, makes sure every part of a missile is in tune with every other part. It accomplishes this unique role in the nation's missile and space program by calibrating secondary standards for each missile

contractor from its own source of primary standards. Before the lab was opened, a survey revealed that 45 per cent of the instruments used were off-standard.

WPSL has the most complete complement of high-precision test instruments available in this country (except for the National Bureau of Standards itself). Standard instruments are housed in a controlled atmosphere laboratory so that neither temperature nor humidity influences testing. Periodically, each instrument is sent to the National Bureau of Standards for checking and recalibration if necessary. Within a few months the laboratory will be equipped to make any sort of electronic or electrical test, including checks of power and frequency of five of the major microwave bands.

Instruments received for test are certified and returned within ten days at no cost to the submitting company. If the laboratory is requested to adjust or repair the instruments prior to certification, a charge is made for that work.

Officially, WPSL is responsible only for Bureau of Ordnance contractors west of the Mississippi. But since no other organization outside of Washington offers a similar service, the laboratory sets the standards for a large part of the nation's missile contractors on an interservice, interagency basis. Navy Ordnance is, however, now setting up a similar laboratory to serve contractors in the eastern states.

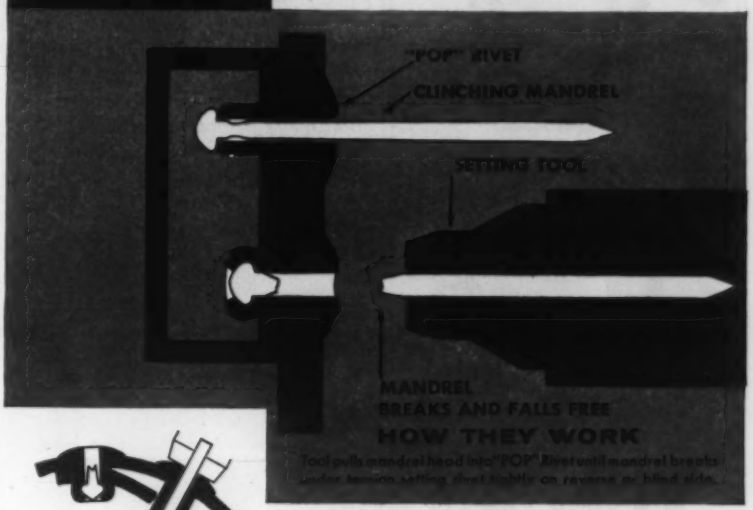
Other People's Patents Good Source for Ideas

WASHINGTON—Patents, those wonderful insurance policies against design piracy, can be first-rate sources for engineering ideas. According to J. Thomas Smith, president, Detroit Harvester Co., Oak Park, Mich., most companies do not utilize the full services of the U. S. Patent System.

Mr. Smith talked on this subject at the recent Industry-Commerce Conference sponsored by the Patent Office. He pointed out that since many brilliant men acknowledge they obtain some of their most orig-

5-Year Study Proves

Each "POP" RIVET Saves 4.9¢ on Installed Costs



High Clinching Action
Pulls parts together with up to 600 lbs. squeeze. Eliminates need to clamp.

Wide Grip Range
Simplifies inventory, purchasing, inspection. Same length "POP" Rivet holds tight through thick or thin.

Vibration Proof
"POP" Rivets cannot back out or become loose. Ensures tight assembly for years of use.

Least Back-Up Space
Strong, high strength "POP" Rivets need only enough back-up space to provide room for set head. Gives more compact design.

Saves 4.9¢ each over other blind rivets

Saves 1.8¢ each over solid rivets

Replace 100,000 solid rivets with strong, high clinch "POP"® Rivets and you save $1,800. Use 100,000 time-tested "POP" Rivets for blind assembly work and you save $4,900.

No other rivet equals the savings potential in *installed costs* provided by "POP" Rivets. The Martin Company saved $223,000 on one fifty-plane contract alone — and with today's rapidly increasing costs, even greater savings are possible. In addition, the extraordinary design flexibility of these rivets gives engineers many opportunities for simplified product design.

Extreme light weight, high production gun — only 2 lb., 3 oz. sharply reduces operator fatigue. Means more rivets set per hour right on the assembly line — rates as high as 1200 per hour even with unskilled operators.

Whether you make planes, missiles, cars, trucks, trailers, metal awnings, furniture, boats, or toys, you can cut costs, simplify design and add assembly convenience with "POP" Rivets. Call or write for our literature now — before you forget. Better still, send a sample assembly for riveting.

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Circle 423 on Page 19

inal ideas, "out of the blue as it were," after mulling over patent-search material, perhaps more engineers could benefit from this technique. Five major arguments recommend close scrutiny of other people's patents:

- Some companies do not publish research results until after patent protection has been obtained, so that many patents serve as an up-to-date source on what is going on.
- Other companies do not publish research results at all, so that patents are sometimes the only source of information.
- A patent review program helps management appraise market potentialities and evaluate likely sources of competition.
- A patent will often contain descriptions of earlier failures of the patentee. This information is available to stop researchers from going up blind alleys.
- A patent claim often indirectly suggests solutions to related engineering problems.

Using the Patent Office strictly for protection amounts to only a half use. It is open for inspection of all patents, except those whose disclosures might injure the national interest.

Meetings

AND EXPOSITIONS

June 1-3—

American Gear Manufacturers Association. 43rd Annual Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from AGMA headquarters, 1 Thomas Circle, Washington 5, D. C.

June 14-18—

American Society of Mechanical Engineers. Semiannual Meeting to be held at the Chase-Park Plaza Hotel, St. Louis. Further information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

June 14-19—

Society of Automotive Engineers Inc. Summer Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Additional information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

June 15-17—

American Society for Engineering Education. Annual Meeting to be held at the University of Pittsburgh and Carnegie Institute of Technology, Pittsburgh. Further information is available from ASEE—Registration, 325 Engineering Hall, University of Pittsburgh, Pittsburgh 13, Pa.

June 16-19—

Institute of the Aeronautical Sciences. National Summer Meeting to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from IAS Headquarters, 2 E. 64th St., New York 21, N. Y.

June 17-20—

National Society of Professional Engineers. Annual Meeting to be held at the Commodore Hotel, New York. Further information is available from NSPE headquarters, 2029 K St., N.W., Washington 6, D. C.

June 18-20—

American Society of Mechanical Engineers. Applied Mechanics Div. Conference to be held at Virginia Polytechnic Institute, Blacksburg, Va. Further information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

June 21-26—

American Society for Testing Materials. Annual Meeting to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Further information is available from ASTM headquarters, 1916 Race St., Philadelphia 3, Pa.

June 21-26—

American Institute of Electrical Engineers. Summer and Pacific General Meeting to be held at the Olympic Hotel, Seattle, Wash. Air Transportation Conference will be held June 22-26. Further information can be obtained from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Circle 424 on Page 19 for Air Valves→

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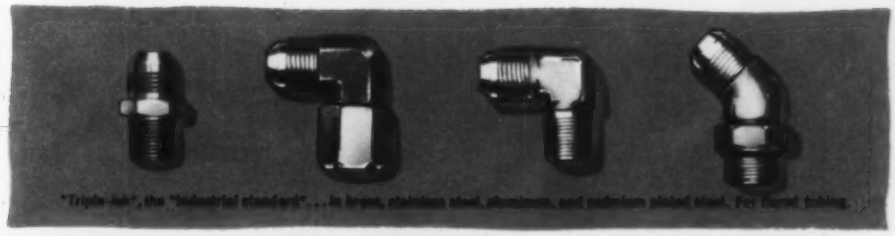

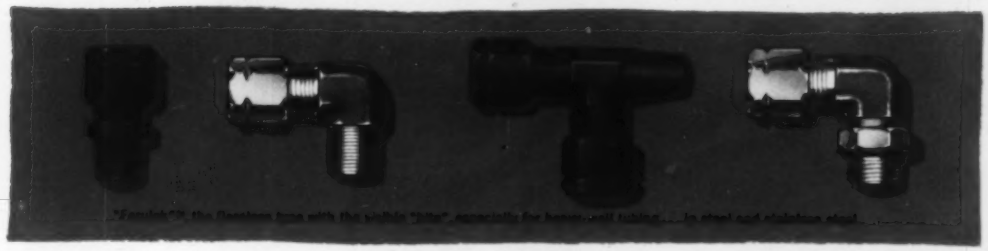

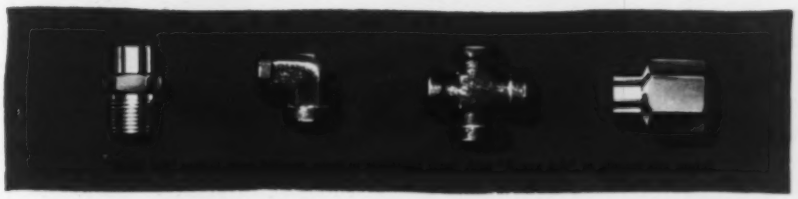

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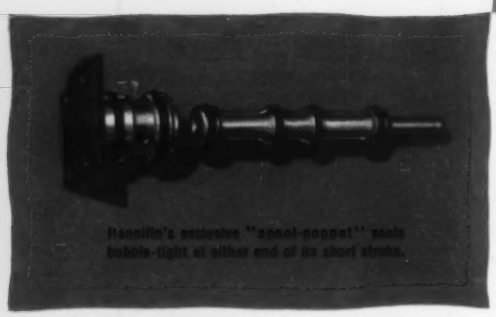

Hannifin's exclusive "spool-poppet" seals bubble-tight at either end of its short stroke.

For complete J.I.C. compliance, valve is electrically inoperative until dust-tight, splashproof solenoid cover is replaced and fastened tightly. Result: no more clogged, jammed solenoids.

One of the versatile—and most popular—Hannifin air control valves is this "CC" series, single-solenoid model. It is available for either ¼" or ⅜" air lines and is gasket-mounted to its own base. This particular base (one of three choices offered) can either be O-ring gasketed to your manifold or mounted over an opening in your bracket or machine. It will receive all four lines from below or take the inlet line from below and the two cylinder lines out one side. Or, you can make all connections at the sides.

When it comes to actuation, Hannifin offers an even wider selection: hand, foot, cam, pressure, single or double solenoid.

When necessary, you can remove this entire valve from its base without disconnecting air lines. Or, the exclusive "spool-poppet" can be replaced without even breaking electrical connections.

The "CC" series, like all Hannifin valves, is designed with "full flow" internal passages as large or larger than its rated pipe size.

You will find these and most other Hannifin valves described in Hannifin's new "Valve Finder." Get your copy from your Hannifin man, listed in the A-Z volume of Thomas' Register, or write:

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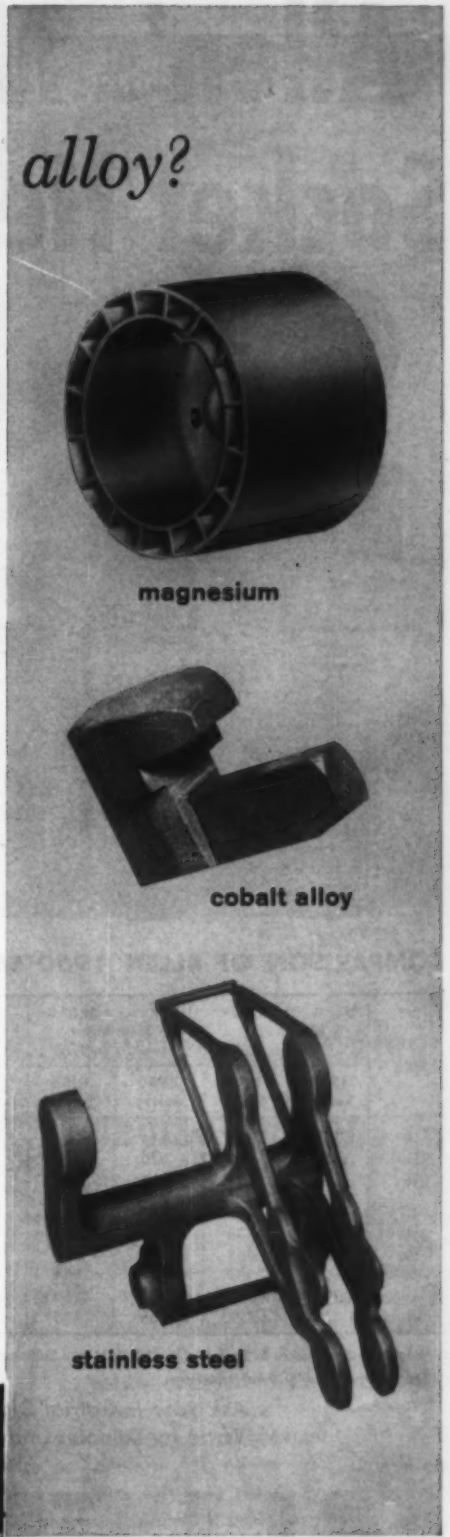

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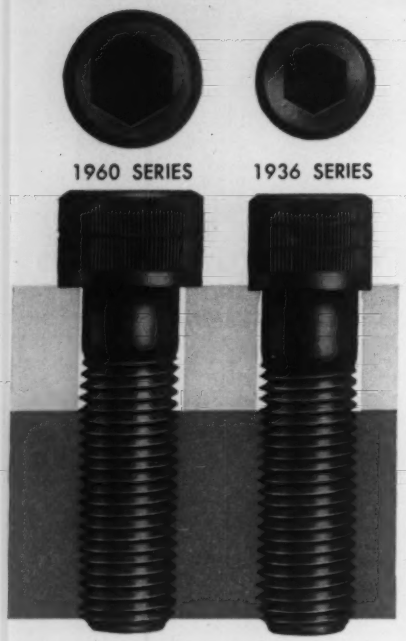
←Circle 425 on Page 19 for Tube Fittings

Circle 426 on Page 19

Allen's *New '60 Series* Socket Head Cap Screws



give up to 2⅓ times more load carrying capacity ...without indentation!

In Allen's new '60 Series, head diameter of sizes from ¼" up is now uniformly one and one-half times the body diameter. In many sizes (where this ratio was not called for by 1936 Series specifications) this will provide *more* under-the-head bearing surface, and a proportionate *increase* in clamping force. Loads are more evenly distributed, and the greater bearing area in many cases eliminates need for washers.

Socket sizes have been increased in many cases—greater wrenching area permits higher tightening torque—which resists fatigue failure, and lengthens the life of the threaded joint.

- A new 2-band knurl will identify all ALLEN Cap Screws (except Stainless Steel) that conform to the new '60 Series specifications. New labels on boxes will also identify these.
- The 1936 Series of Allen Cap Screws will continue to be available.

COMPARISON OF ALLEN 1960 SERIES AND 1936 SERIES SOCKET HEAD CAP SCREWS

SCREW SIZE	HEAD DIAMETER Minimum (inches)		BEARING SURFACE Minimum (square inches)		PERCENT OF INCREASE IN BEARING SURFACE[1]	TENSILE LOAD TO INDENT IN SOFT STEEL[2] (lbs.)		TORQUE INDUCED TENSILE LOAD TO INDENT IN SOFT STEEL[2] (lbs.)	
	1960 Series	1936 Series	1960 Series	1936 Series		1960 Series	1936 Series	1960 Series	1936 Series
¼	.365	.367	.044	.044	—	4,750	4,750	2,780	2,780
5/16	.457	.429	.070	.052	33	7,440	5,600	4,380	3,300
⅜	.550	.553	.111	.111	—	12,100	12,100	7,000	7,000
7/16	.642	.615	.140	.103	36	15,000	11,000	8,850	6,450
½	.735	.739	.183	.183	—	19,500	19,500	11,500	11,500
9/16	.921	.863	.293	.216	35	31,000	23,200	18,500	13,600
¾	1.107	.987	.424	.224	89	45,000	24,000	26,700	14,100
⅞	1.293	1.111	.585	.253	131	62,500	27,000	36,800	15,900
1	1.479	1.297	.768	.405	89	82,000	43,500	48,500	25,500

[1]Head tolerance revisions on Sizes #0 thru #10, ¼, ⅜, and ½ diameter have no significant effect on bearing surface or holding power of screws.
[2]Values based on .00025 inch indentation.

Ask your Industrial Distributor about ALLEN '60 Series Cap Screws.
Write for samples and complete specifications. Ask for Bulletin G-25.

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ALLEN HEX-SOCKET SCREWS HEAD

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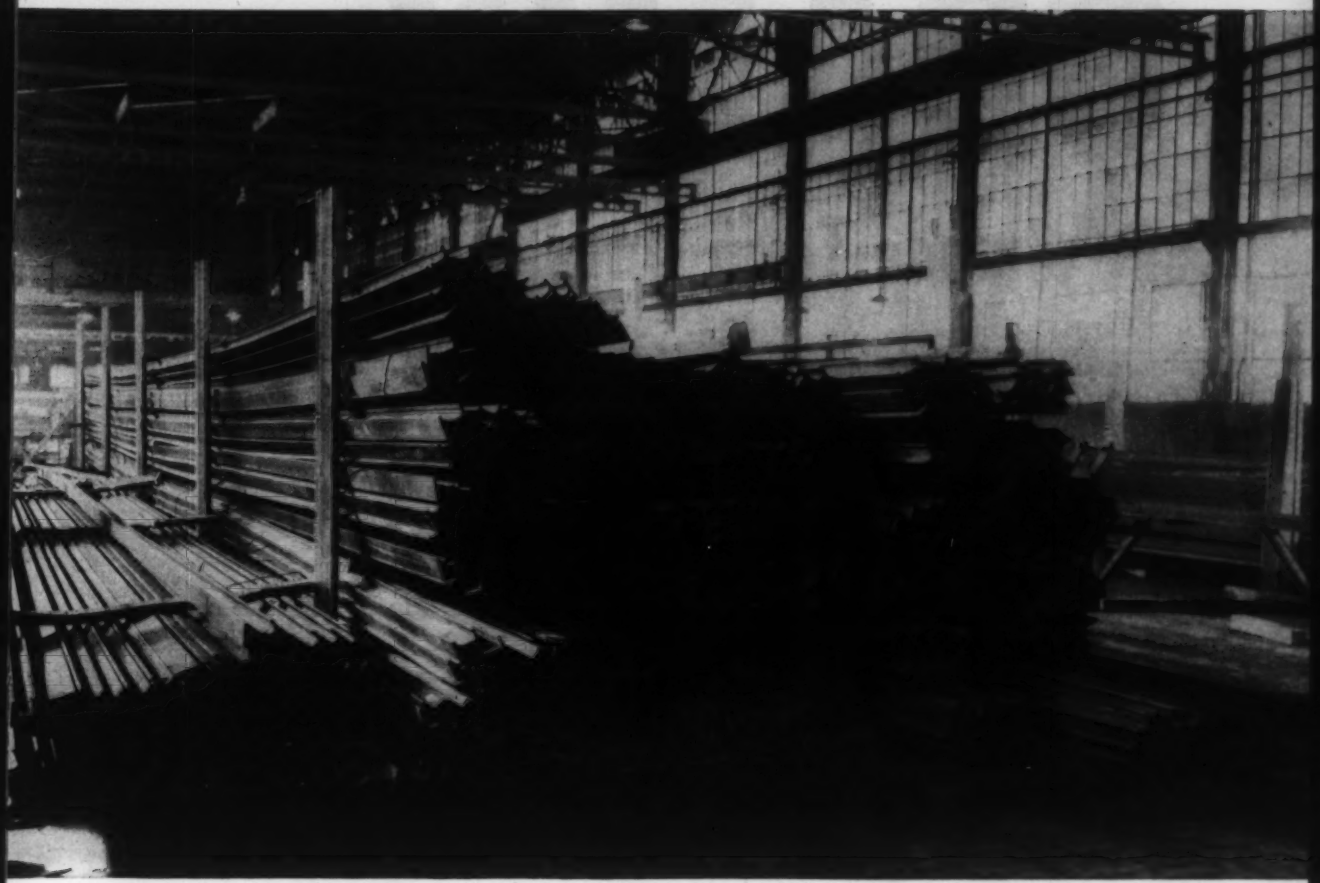

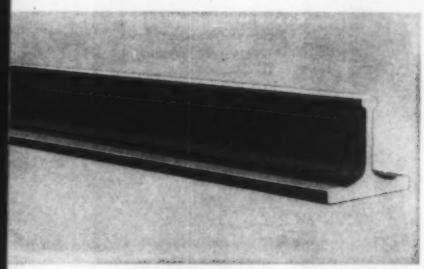

A one-piece rail rolled for the runway of Cleveland Tramrail Systems. This track has flat raised treads designed to minimize peening. No machining is required on this USS Special Section.

USS

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Tennessee Coal & Iron—Fairfield, Alabama
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United States Steel

Tramrail—non-peening, no machining made from USS Special Sections

This supply of rails for Cleveland Tramrail Systems represents a cost saving running into many thousands of dollars. They are USS Special Sections rolled to exact size and cut to proper length. If the rails had to be machined from bars of high-carbon or alloy steel, the cost would be prohibitive and scrap losses tremendous.

The steel is furnished in a high carbon grade which serves to minimize track wear caused by wheel peening on the track tread. The manufacturer says that in 30 years no other overhead track has been offered that surpasses this one for durability.

It's seldom that better products can be produced at substantially lower costs but that's what happens when you use rolled USS Special Sections. Rolled to the predominating cross section needed, it is a custom-tailored part, designed and rolled so that there is little or no finishing required to meet final specifications.

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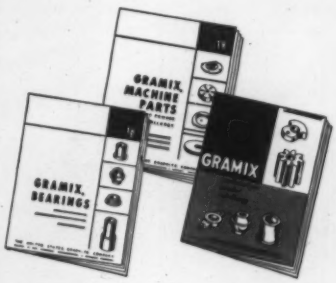

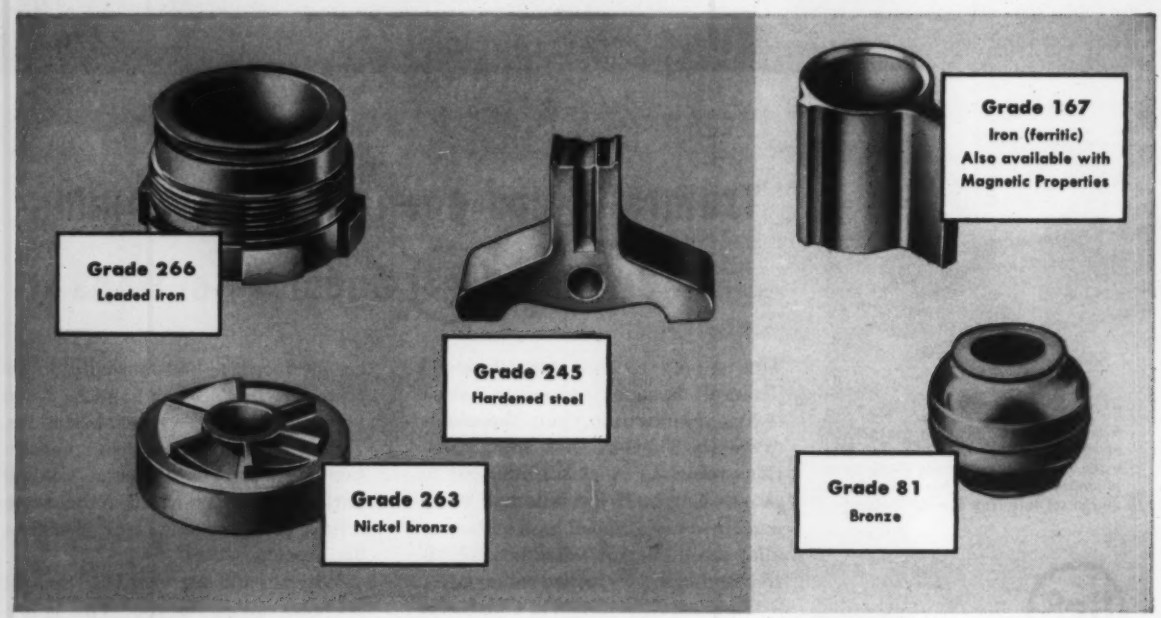

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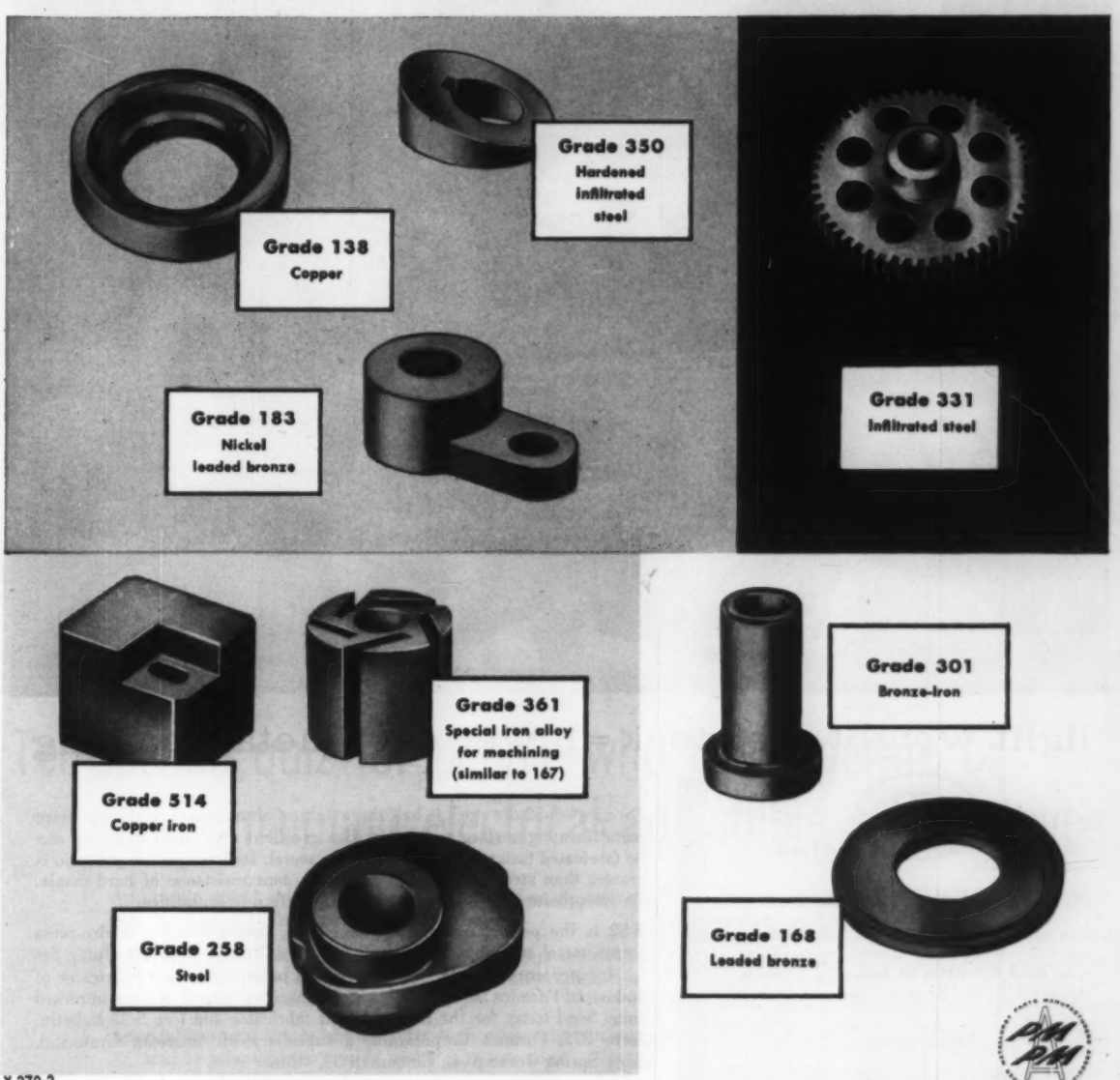

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Circle 429 on Page 19

YES

OR

Ten-second quiz for people who buy, operate or maintain electrical adjustable speed drives

YES	NO	
☐	☐	Adjustable speed drives should be simple to install, operate, and should require little or no maintenance.
☐	☐	Adjustable speed drives should offer a wide range with either constant torque or constant hp, and should offer smooth acceleration and deceleration.
☐	☐	Adjustable speed drives should offer high operating efficiency . . . and be adaptable to a wide range of motor sizes.
☐	☐	Adjustable speed drives should provide the required flexibility and inherent reliability for any type of application . . . intermittent or continuous.

If you have answered "yes" to the above questions, then you will be very much interested in obtaining complete information about the *all-new, static-powered* Westinghouse Adjustable Voltage Reactifier drive . . . (Type AVR). This new drive not only meets all of the above requirements, but also gives you many other advantages to perform a better job at lower cost. Ask your Westinghouse sales engineer to show you exactly where and how this new drive can benefit you. Or, write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

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Circle 430 on Page 19

Memo on Metals

Crucible Alloy Offers High Impact Strength, Hardness at 220-240,000 psi Strength Levels

Today's ultra-strength steels possess a unique combination of mechanical properties even when they are used at their ultimate levels of tensile strength. One of the first steels developed in this class — Crucible HY-Tuf® — combines high impact strength, hardness and good ductility at the 220,000/240,000 psi range.

HY-Tuf (1.8% Ni, 1.30% Mn, 1.50% Si, 0.40% Mo) was first widely used in aircraft applications because of its favorable strength-weight ratio. But, because it is also tough and hard, it has rapidly found its way into power-driven garden tools, hand- and power-operated banding machines, rock bit bodies, cutter head bolts, couplings, pinion gears and shafts.

HY-Tuf's high impact strength, especially at high levels of tensile strength or hardness, has been demonstrated in a great number of tests. These tests prove HY-Tuf definitely superior to standard AISI alloy steels in impact strength and ductility at hardnesses above 42 Rc or tensile strengths above 190,000 psi. For specific comparisons, see Figures A and B.

FIG. A—TENSILE AND IMPACT DATA

Grade	Temper	Rc	Tensile Strength, psi	.2% Yield Strength, psi	.01% Yield Strength, psi	% Elong. in 2 in.	% Red. of Area	Izod Impact Ft-Lb
HY-Tuf	550F	46.5	234,000	193,000	154,000	13.1	49.7	31
4340	700	46	228,000	212,000	210,000	11.2	47.8	17
4140	800	46	227,000	205,000	198,000	11.2	39.4	8
9442	700	46	225,000	203,000	200,000	10.3	43.4	11

Oversize .505" dia. tensile specimens and finish machined Izod specimens were oil quenched from the conventional austenitizing temperatures and tempered as indicated.

FIG. B—MAXIMUM IMPACT PROPERTIES
(at hardness of Rockwell C45 or greater)

Grade	Izod			Tension Impact			
	Ft-Lb	Temper	Rc	Ft-Lb	Elong.	Temper	Rc
HY-Tuf	33	400F	47.5	195	16	None	47.5
4340	13	860	45	158	12.2	400F	55
4140	17	500	52	160	14	375	55
8630	19	400	51	148	14	200	52.5
4130 (oil)	17	500	47.5	133	14.5	200	50
4130 (water)	21	450	50	142	13.0	200	52.5

The alloy's superior ductility is shown by these slow bend tests performed on ⅞" rod bars heat treated to 47 Rc.

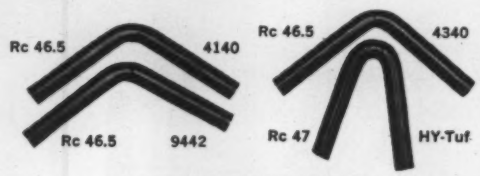
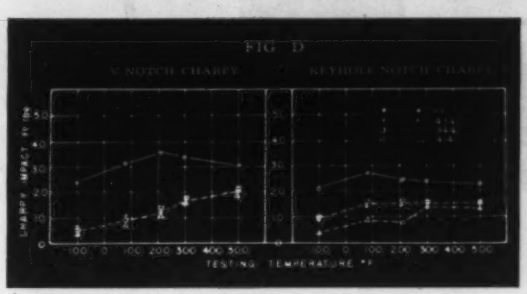


FIG. C—BEND TESTS
Bars — ⅞" rd.

HY-Tuf's notch sensitivity is much lower than that of conventional steels at hardnesses of 45 to 47.5 Rc. Unlike other alloys, HY-Tuf has higher impact values for the V-notch Izod test than for the keyhole Charpy test. This is important because it means that HY-Tuf is much less sensitive to a notch at high strength levels than ordinary steels.

Crucible HY-Tuf conforms to MIL-S-7108 and AMS 6418 and is available in commercial sizes and quantities. For more information on this ultra-strength alloy, send the coupon.

* *ultra-strength steel's impact strength, hardness*
* *titanium price reductions*
* *permanent magnet handbook*



Effect of testing temperature on the notch impact values of HY-Tuf and conventional steels heat treated to 47 Rc.

New Low Prices of Titanium Mill Products Justify Using The Alloy in More Applications

Early this year Crucible's Titanium Division announced new price reductions for its titanium mill products – that cut these prices to *a new industry low*. The reductions, as much as 25%, affected both base prices and the costs of "extras".

For example, sheet was cut from $9.10 per pound base price to $7.50. Strip was reduced $1.25 per pound to $7.25. Plate, formerly $6 per pound, now costs only $5. Crucible also slashed billet prices to $3.55 per pound and wire to $5.50 per pound. Bar items were reduced $1.00 per pound to $4.25 (base price). In addition, some size "extras" were reduced as much as 55%, and finished "extras" by over 40%.

Because of these lower prices, engineers can now utilize titanium's unique properties in many more applications and justify the selection economically. (Even at previous prices, titanium often proved itself the low-cost metal on a cost-per-service-year basis.) This should prove especially true in processing applications requiring corrosion resistance and long-service life, and in aircraft and missile applications where high-strength, lightweight materials are essential.

During the past five years, titanium fabricating costs have also been cut substantially because of experience gained in forging, machining, welding and forming. ***For detailed information on Crucible titanium mill products, send the coupon.***

Permanent magnet handbook: 346 pages of design data

One of the most comprehensive manuals ever published on permanent magnets is available through Crucible Steel Company.

The *Permanent Magnet Handbook* contains all the data needed to design magnets into generators, meters, compasses, chucks, couplings, hi-fi and television components, and thousands of other products. It also contains entire sections on permanent magnet measurements, ferromagnetism, magnetization, demagnetization and electro-magnetic theory. It gives the complete performance and property data of over 60 different magnet materials: such as, magnet steels, Alnico alloys, and Ferrimag ceramics.

To cover actual printing costs, a nominal sum of $10.00 is being charged for each copy. However, this sum also covers the cost of additions to the handbook – mailed to subscribers each time new Crucible data become available.

For your copy, send the coupon and check or money order for $10.00. If you are located in Pennsylvania, add 30¢ for state sales tax.

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Gentlemen:
Please send me the following:

1. Crucible HY-Tuf Data Sheet ☐
2. Further information on titanium mill products ☐
3. Permanent Magnet Handbook (Enclose check or money order) ☐

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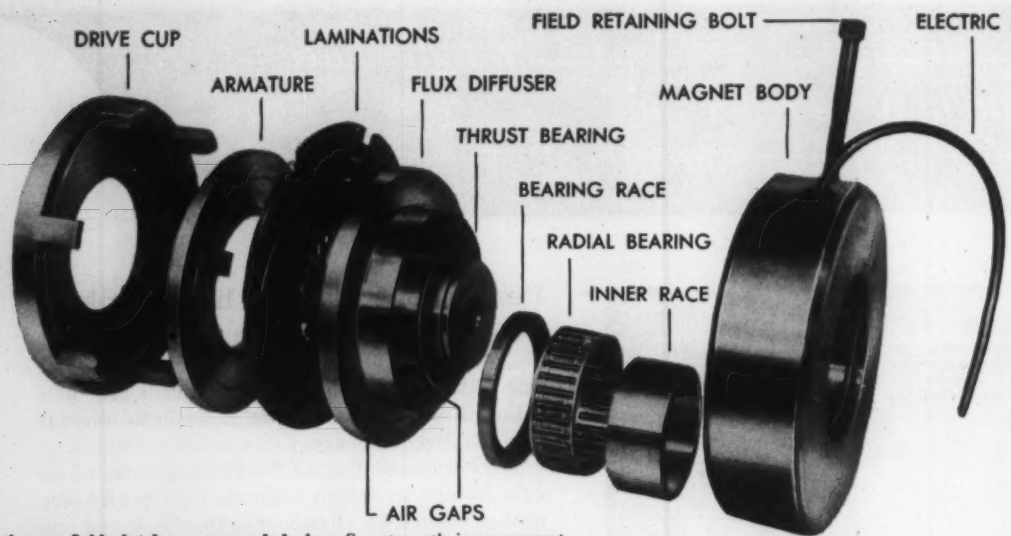
Circle 431 on Page 19



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DURABILITY

The *durability* of I-T-E Electro-Clutches is one of the big reasons for making them your choice. Bearing life is equal to machine life. Each design of clutch is operated 100,000 times before torque rating is determined. After that, it is required to run several hundred thousand additional operations without loss of torque or need for maintenance of any kind. Nothing matches them.

FAST, FIRM CLUTCHING

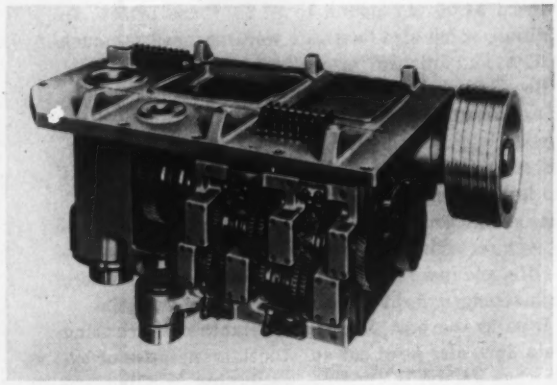
Clutching action takes place between interleaved laminations of *hardened steel* . . . not friction material or sintered nonferrous metals. The clutch lasts as long as the machine. No other clutch on the market offers such durability. In addition, because it has a fixed air gap, there are never any adjustments or loss of performance with age.

NEW MODEL NEVER NEEDS UPKEEP

Recently I-T-E introduced the *stationary field* Electro-Clutch that does away with the slipring and brush. So there is never anything to service. And never anything to replace. This means that designers can bury the clutch deep inside a drive box or transmission . . . for access is never needed. For easy assembly, they slide right on the shafts as one unit.

WIDE RANGE OF TYPES AND SIZES

I-T-E Electro-Clutches are available to fit your own shafts and in torque ratings from 3.2 to 13,000 lb-ft. Stock voltage ratings are 24 and 90 v d-c. Other control voltages provided on request. Write for complete details. I-T-E Circuit Breaker Company, 1900 Hamilton St., Philadelphia 30, Pa.



They go inside with the gears and the oil. This is the main transmission of a Fosdick Precision Jig Borer. You can scarcely see the 13 standard I-T-E Electro-Clutches. But they are there . . . mounted right on the same shafts with the gears. Because they operate in an oily atmosphere, they save transmission space and simplify design.

I-T-E CIRCUIT BREAKER COMPANY

Circle 432 on Page 19

B.F.Goodrich

RIVNUTS®

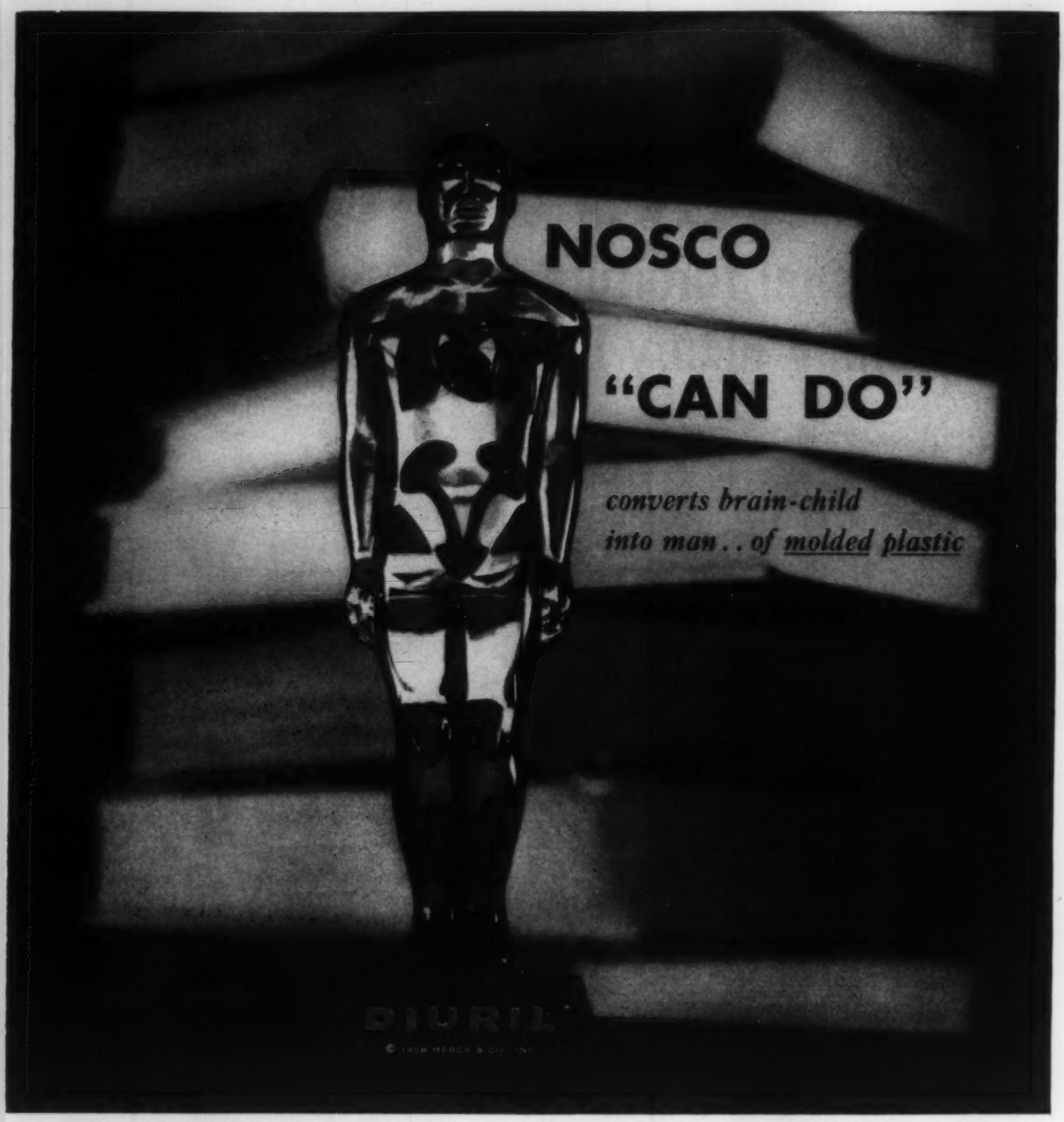
give casual furniture fast selling luxury look

Durham Manufacturing Corporation preserves the clean, functional lines of its modern tubular furniture with B.F.Goodrich Rivnuts. Rivnuts eliminate unsightly nuts and bolts, speed assembly, add sales appeal.

Durham switched to B.F.Goodrich Rivnuts at key points in its complete line of casual furniture, including the inviting DURelaxer above. Rivnuts with countersunk heads are upset inside the tubular legs (see drawings). They provide high-strength nutplates for unobtrusive attachment screws. Crimped, lock-type ends prevent screws from backing out.

Only B.F.Goodrich Rivnuts give you firm, blind nutplates for tubular applications. So if you want to do a smoother fastening job, or want to fasten faster and at less cost, use B.F.Goodrich Rivnuts. Send now for free data booklet. *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Dept. MD-59, Akron, Ohio.*

B.F.Goodrich ***aviation products***



This was the brain-child of Merck Sharp & Dohme, pharmaceutical manufacturer. They showed Nosco a sketch and said "Make us a man, six inches tall; a small plastic figure to introduce doctors to 'DIURIL,' a new drug which controls the body's fluid content." The figure had to be fluid-filled and transparent to show the internal organs.

How did Nosco "Can Do" make a man? First we built a prototype by hand, then refined the design many times to facilitate volume production. The figurine is molded of cellulose propionate plastic in a Nosco-designed, two-unit mold. Each finished figure contains five parts. Nosco's finishing department painted the tiny heart, lungs and kidneys, hot-stamped the trade name, cemented the internal organs, assembled the front and back body sections, filled the figure with fluid to a pre-specified level, cemented the plug in place, packed both individual and shipping cartons . . . and we had our man! *Rate of assembly: 3000 per shift!*

The toughest part of Nosco's job was to prevent leakage. Here's how successful we were: Nosco quality control delivered over 99.9% non-leaking, *perfect* pieces. Nosco likes tough jobs . . . likes to turn *your* brain-child into reality in practical plastics. For more information about Nosco "Can Do," just write or call.

NOSCO plastics, inc. • erie 2, pa. *World's largest injection molding plant*

Circle 434 on Page 19

SIMPLIFY MACHINE DESIGN WITH THIS *Complete* AIR CYLINDER

Save design time — save production costs. Eliminate cams, levers, gearing, linkages or other mechanical means for performing push, pull or lift motions. Design with air in mind.

The Bellows Air Motor is a complete electrically-controlled air cylinder power unit with directional valve and speed controls built in. It requires only one air connection which can be made with flexible hose. Compact, space saving, it fits well into crowded quarters or on moving machine elements. It is fast, responds to a starting impulse instantly. It is easily interlocked and synchronized with related machine movements. Its quality and reliability has been proven in more than quarter of a million installations.

The range of work it can do is limited only by the imagination of the design engineer.

Send for this free booklet

Here in these quick reading pages is the full story of The Bellows Air Motor — what it is doing for others, what it can do for you. Address Dept. MD-559 The Bellows Co., Akron 9, Ohio. Ask for Bulletin BM-25. In Canada, write Bellows Pneumatic Devices of Canada, Ltd., Toronto, Ontario.

The Bellows Co.

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

AKRON 9, OHIO

7658-2

OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio

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whatever hydraulic problem has you stumped. A trained Denison Hydraulic Specialist is ready to sit down with you and analyze your problem.

2. WE'LL DEVELOP YOUR CIRCUIT...

the most efficient hydraulic circuit to handle your specific needs. We can do this while you wait.

3. PICK OUT WHAT YOU NEED...

right off the shelf — from Denison's complete stock of hydraulic pumps, motors, valves and controls to 5000 psi.

4. TAKE HOME YOUR COMPLETE HYDRAULIC SYSTEM...

ready to go to work for you! Complete hydraulic circuit drawings and hydraulic parts are "under your arm" in a *complete package.*

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Circle 436 on Page 19

PHOTO BY KAREN OF OTTAWA

"To achieve best design results—we must have steel of consistent quality"

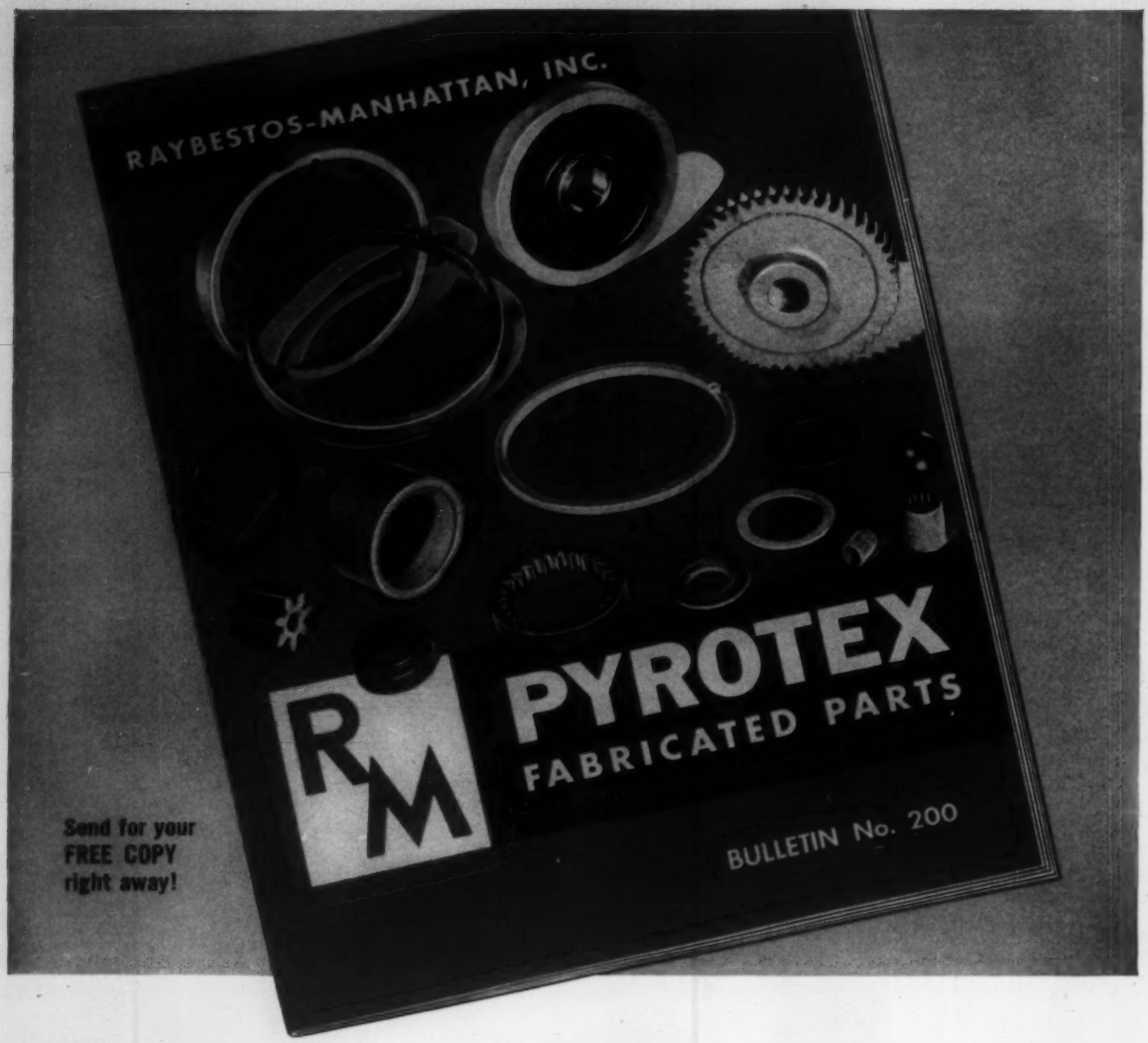
—J. W. HUBLER, vice president engineering, Macomber Incorporated, Canton, Ohio.

"Engineers of construction products rely heavily on sources of material supply"—says J. W. Hubler, vice president of engineering at Macomber, one of the nation's foremost manufacturers of steel joists, roof decking, and structural steel framing.

"Because the relation of strength to weight is vitally important in the construction business, we design to give the architect the strongest, lightest, easiest-to-use product possible. To do this we must be sure the steel is right—every inch of it. For steel of consistent analysis and quality, we can rely on *Sharon Steel Corporation, Sharon, Pa.*"

SHARONSTEEL **SHARON** *Quality* **STEEL**

Circle 437 on Page 19



R/M Pyrotex Parts—High in Performance, Low in Cost

R/M's Pyrotex fabricated parts are economically laminated, molded or machined to rigid specifications. Pyrotex can reduce the cost of many precision parts. An asbestos-reinforced thermosetting plastic, it has a high modulus of elasticity and strength, resists heat, chemicals and water, and has exceptional dimensional stability.

R/M Pyrotex parts are highly successful in the automotive, industrial, aircraft, rocket and missile fields. Investigate. Learn how you can profit from R/M's modern facilities for quality-controlled fabrication of precision parts. Send today for a copy of the latest technical bulletin containing valuable data on the properties and applications of Pyrotex parts.

R/M
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RAYBESTOS-MANHATTAN, INC.

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Circle 438 on Page 19

Please direct inquiries to advertiser, mentioning MACHINE DESIGN→

Modern Variable Speed Fresh new look and improved performance to a time-tested and proved product. Reeves Vari-Speed Motodrives are now available in this smart design . . . ¼ thru 20 hp. . . . 2:1 thru 10:1 speed variation . . . 1.8 thru 4660 rpm. A compact power package for infinitely variable output speeds designed and engineered to meet virtually every production need. Hundreds of space-saving standard assemblies: output shaft on same side or opposite side of motor; vertical, 45°, horizontal and trunnion models; no reducer, and single, double, or triple stage reductions. Full range of modifications, accessories, and manual, remote, or automatic controls.

New 96-Page Catalog Complete data on sizes 100-500 (¼-20 hp.) and sizes 8000 (25-40 hp.). Prices included. Write today—on your company letterhead—for your copy.

REEVES PULLEY COMPANY
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.
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R MASTER
REEVES

BARKSDALE AIR-SEAL* VALVES

LOW PRESSURE AIR TO 250 P.S.I.

. . . over 200 different valves available.

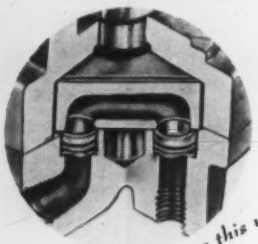
The air pressure is the sealing force . . . the higher the pressure, the tighter the seal.

Why so many different air valves?

Because air valve requirements vary with the method of actuation. A basic valve with interchangeable actuators cannot possibly meet ALL your specific applications without compromise. For example: A solenoid valve designed for speed would not have the stamina required of a manual or foot valve.

The Barksdale line of AIR-SEAL Valves has been designed with your requirements in mind. All our valves have been engineered for best performance from your point of view . . . for YOUR specific need, and not to make OUR job easier.

MANUAL and FOOT OPERATED "SHEAR-SEAL" VALVES



No oilers and filters needed — not critical to dirt and corrosion — made from non-corrosive materials.

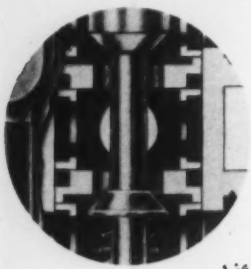
Years of leakproof service — without constant maintenance — Self aligning "Shear-Seal" design compensates for normal wear.

compare this with conventional SPOOL or PLATE VALVES

Alignment is critical — dirt and corrosion cause sticking.

There is no compensation for normal wear — leakage increases with use.

SOLENOID-PILOT CRESCENT® (Self-aligning poppet) VALVES



Quick response (12 milliseconds) due to short travel of poppets and solenoid.

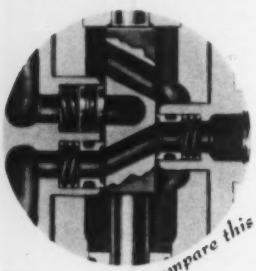
Tight sealing — self-aligning, self-scavenging design adjusts to normal wear — not critical to dirt and corrosion — non-corrosive materials throughout.

No coil burnout — heat dissipating "integral" design.

compare this with conventional SPOOL VALVES

Slower response due to long spool travel. Leakage increases with use — dirt and corrosion particles are ground-in between spool and seals—Sticking! Overheating causes coil burnout — poor heat transfer of "unitized" design.

DIRECT-SOLENOID OPERATED "SHEAR-SEAL" VALVES



Leakproof for years of service — self-adjusting to wear. No coil burnout — because valve does not freeze up.

compare this with conventional SPOOL VALVES

Dirt enters spool clearances — develops leaks — causes sticking — sticky valves are to blame for most solenoid burnout.

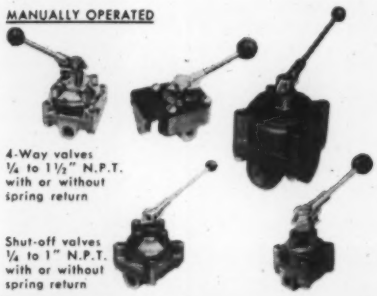
Write for Air Valve Catalog 9-AV

CONTROL VALVE DIVISION

Barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

MANUALLY OPERATED



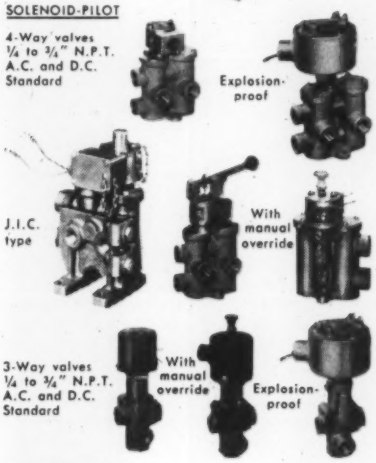
4-Way valves ¼ to 1½" N.P.T. with or without spring return

Shut-off valves ¼ to 1" N.P.T. with or without spring return

FOOT OPERATED

4-Way valves ¼, ⅜ and ½" N.P.T. with or without spring return

SOLENOID-PILOT



4-Way valves ¼ to ¾" N.P.T. A.C. and D.C. Standard

Explosion-proof

J.I.C. type

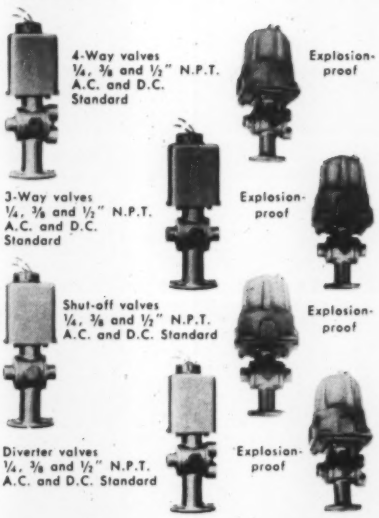
With manual override

3-Way valves ¼ to ¾" N.P.T. A.C. and D.C. Standard

With manual override

Explosion-proof

DIRECT SOLENOID



4-Way valves ¼, ⅜ and ½" N.P.T. A.C. and D.C. Standard

Explosion-proof

3-Way valves ¼, ⅜ and ½" N.P.T. A.C. and D.C. Standard

Explosion-proof

Shut-off valves ¼, ⅜ and ½" N.P.T. A.C. and D.C. Standard

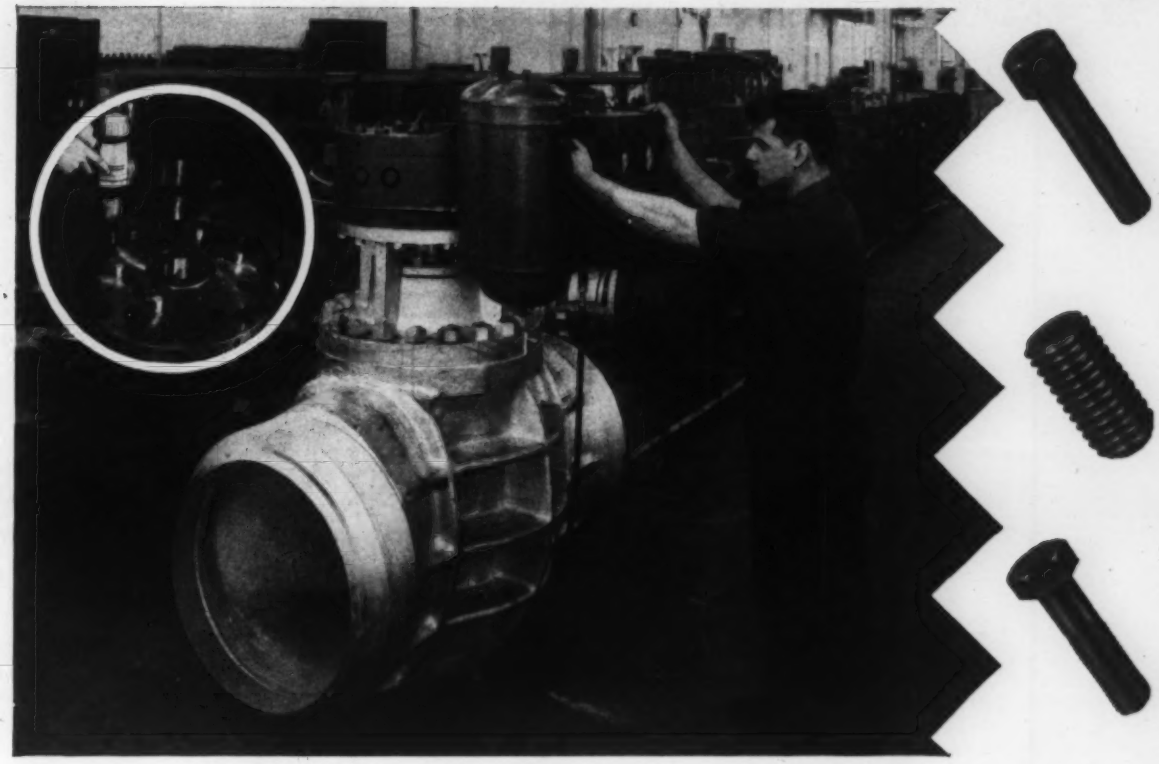
Explosion-proof

Diverter valves ¼, ⅜ and ½" N.P.T. A.C. and D.C. Standard

Explosion-proof

Circle 440 on Page 19

IT PAYS TO STANDARDIZE ON STANSCREW



Stanscrew service adds strength, lowers costs for Shafer Valve Company

The valve operators produced by Shafer Valve Company of Mansfield, Ohio are used to open and close large valves on gas pipe lines . . . often in remote locations, many miles from human supervision. They are subject to sudden surge loads which cause extremely high stresses . . . and their critical importance demands unfailing reliability of all components.

Shafer formerly manufactured their own fasteners for this demanding application from a special high strength steel. Then their distributor arranged for a visit from Stanscrew's fastener specialist. He quickly established that Stanscrew's heat-treated "Carbon Restoration" cap screws, correctly applied, could provide even greater fastener strength . . . and at a significant saving in cost.

The Stanscrew fastener specialist may be able to make similar savings or improvements in your assembly operations. For he brings to your application the experience and facilities which have made Stanscrew a leading supplier of fasteners to the top names in American industry for over 80 years. And he can select money-saving answers to your problems from a complete line of over 5,000 different types and sizes of standard fasteners . . . always in stock, quickly available.

Whatever your fastener requirements, call your nearby Stanscrew distributor today. He will arrange for a prompt visit from the Stanscrew fastener specialist.

STANSCREW FASTENERS

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS
HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT
WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

STANDARD SCREW COMPANY 2701 Washington Boulevard, Bellwood, Illinois

Fluid mapper pattern demonstrating liquid flow through a cross section of a Malleable differential carrier.

Versatility is Malleable

The ability to do most any job well is synonymous with Malleable iron castings. The variety of tasks they perform, from the commonplace to the spectacular, is legend. The strength and toughness . . . the freedom of design . . . the wide range of shapes and sizes . . . the excellent machinability . . . the economies achieved . . . all these advantages of Malleable combine to create an unexcelled reputation for versatility.

Whatever your needs, look first to Malleable.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

Versatility Is Key to Malleable's Increasing Use

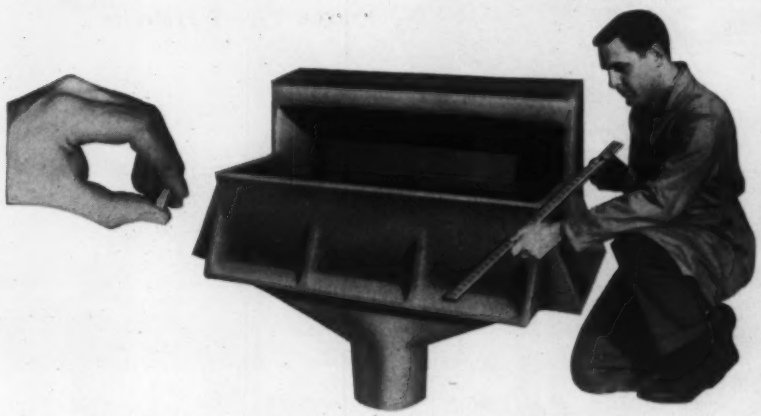
Recent metallurgical advances have made the Malleable irons a family of metals uniquely capable of meeting the most diverse design, production and performance requirements. Whether the vital consideration is high strength, toughness, ductility, hardness, machinability, high or low temperature performance, wear resistance, or economy and adaptability for complicated designs, Malleable castings have the versatility to meet exacting specifications.

For versatility of shape, the casting process is unexcelled. It permits direct production of the most complicated components. The metal is placed exactly where it is needed regardless of the intricacy of the design.

The capabilities of the metal to be cast are of even greater significance, for every application has a different set of requirements. Here, Malleable iron provides unique opportunities to obtain better parts at less cost.

Holes can be punched in Malleable, surfaces can be coined to meet rigid specifications. The pearlitic Malleables can be surface-hardened for even better wear resistance. These and other advantages make today's Malleable iron one of the most versatile engineering materials available.

Although Malleable iron's properties are flexible, depending on service requirements, certain relationships remain constant. Malleable provides more strength and toughness per dollar than any other metal. It is also the most machinable of all ferrous metals of similar properties.



Malleable castings can be produced in sizes ranging from the hammer handle wedge, shown here, weighing less than an ounce, to the 1,125 pound bridge scupper. Throughout this range is an endless variety of castings, best made of Malleable for highest quality at lowest cost.

Shapes and sizes of Malleable castings are virtually limitless. The combination of Malleable's good castability with modern production techniques regularly results in sections as thin as 1/16" and tolerances of ±.005" per inch in sections of 1", with excellent surface finishes.

Engineering Aids Available

While the design of Malleable castings is not complicated, it will pay you to consult a skilled Malleable engineer who can offer time and cost saving suggestions for the production of better parts. As another aid to basic Malleable casting design, a special folder — *Data Unit 104 — Design Versatility* — is available from any member of the Malleable Castings Council and from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
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ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
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Link-Belt Company, Indianapolis 6
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Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
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Laconia Malleable Iron Co., Laconia

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Meeker Foundry Company, Newark 4

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Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

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Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
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Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

Circle 442 on Page 19

Now!

GET TOTAL MOTOR BURNOUT PROTECTION* AGAINST ALL POSSIBLE CONDITIONS THAT CAUSE OVERHEATING WITH KLIXON TYPE T PROTECTED MOTORS

Manufacturers of motor driven equipment can obtain induction motors that have *complete protection against all possible conditions that cause overheating and burnouts* simply by specifying on their motor purchase order — "These motors to have KLIXON Type T Protectors".

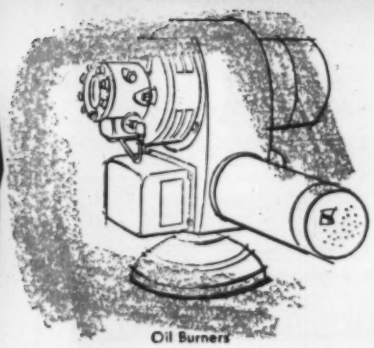
Built-in as an integral part by the motor manufacturer, the KLIXON Protector permits maximum overload performance with safety by safeguarding the motor against all abnormal operating conditions beyond the control of the manufacturer. These include: low voltage, blocked ventilation, high ambient temperature, stalling, excessive overload, improper current supply, jammed load, faulty belts or couplings, improper lubrication, electrical component failure, mechanical failure and improper installation.

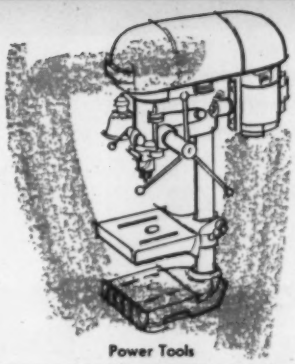
Here's what *complete protection* gives you — safe maximum motor output without premature motor failure, reduced motor repairs, replacements and service calls.

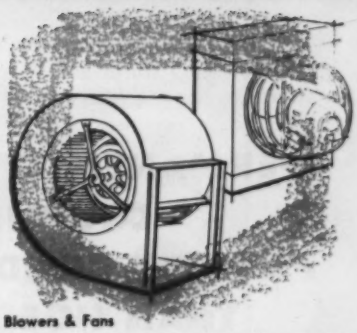
NO OTHER PROTECTOR PROVIDES 6-WAY COMPLETE PROTECTION

Most conventional protectors used today may protect motors against up to four overheat conditions. KLIXON Type T Protectors safeguard motors from *all* six conditions:

1. Running overload with or without high ambient or ventilation blocked.
2. Locked rotor normal voltage such as caused by mechanical failure of driven load.
3. Locked rotor caused by low voltage where decreased torque is insufficient to start load.
4. Locked rotor with main winding only in circuit resulting from open circuit start switch failure or open circuit in reversing switch.
5. Locked rotor with start winding only in circuit, such as that resulting from an open main winding circuit or open circuit in reversing switch.
6. Running with both start and main windings in the circuit resulting from start switch failure in closed position or low voltage which prevents reaching switch-over speed.


Oil Burners


Power Tools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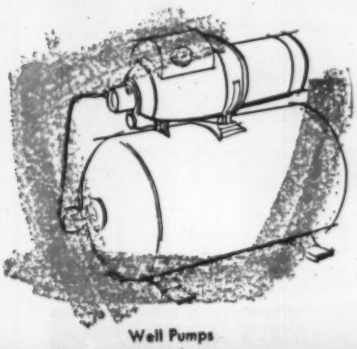
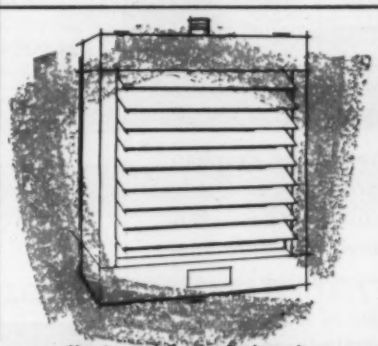
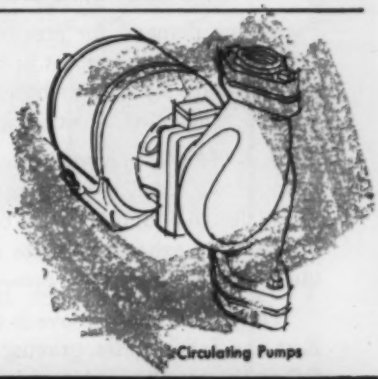

Well Pumps


Heating and Cooling Equipment


Circulating Pumps

Over 150,000,000 motors are protected against overheating and burning out with KLIXON PROTECTORS

METALS & CONTROLS CORPORATION

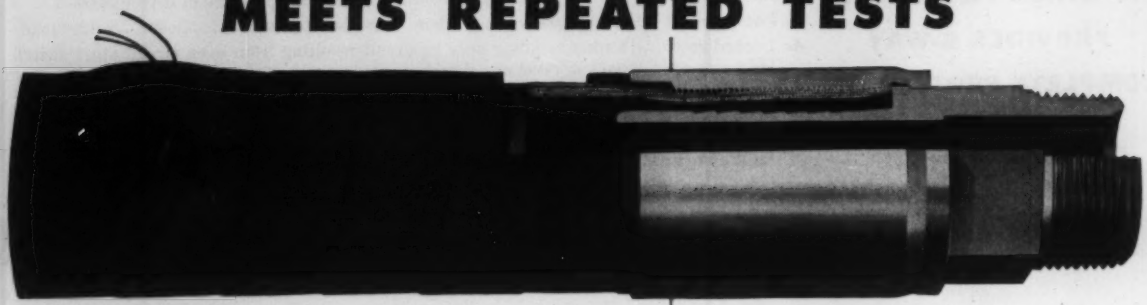
Spencer Division

3205 Forest St., Attleboro, Mass.

KLIXON®

Circle 443 on Page 19

Eastman APPLICATION MEETS REPEATED TESTS



Tests prove that Eastman couplings applied to super high pressure 4-ply spiral wire hose assure successful assemblies. Couplings hold well above minimum burst pressure.

PERMANENTLY ATTACHED COUPLINGS PROVIDE BOND STRONGER THAN HOSE ITSELF!

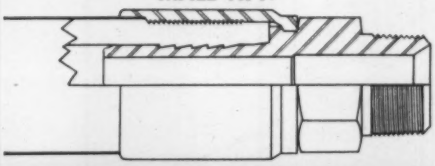
Increasing demand for greater power brought about the use of higher pressures in hydraulic systems. This not only calls for greater hose strength, but far more critical engineering in coupling design and application.

EASTMAN is contributing toward the development of the trend toward higher pressures—not only in the design and application of coupling to hose—but in the more exhaustive tests required to assure adequate safety under high pressure operations.

The actual photo above is typical of many tests in Eastman laboratories proving that the hose did not fail at the coupling—demonstrating that the coupling was designed and applied to form *a bond which was stronger than the hose itself.*

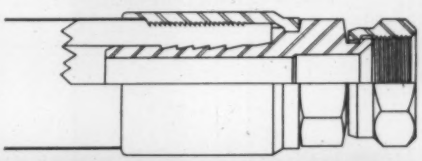
If you have an application requiring higher pressures, let our engineering department demonstrate the superiority and economy of Eastman applications, and quote on complete Hydraulic Hose Assemblies.

MALE NPTF



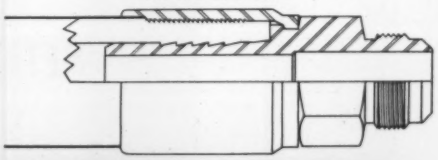
Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12M	¾	1 7/16	19/32	20,000	5,000
8416-16M	1	1 ¾	25/32	16,000	4,000
8420-20M	1 ¼	2	1 3/64	12,000	3,000
8424-24M	1 ½	2 ¼	1 21/64	10,000	2,500

SWIVEL FEMALE JIC-37°



Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12FH	¾	1 7/16	19/32	20,000	5,000
8416-16FH	1	1 ¾	25/32	16,000	4,000
8420-20FH	1 ¼	2	1 3/64	12,000	3,000
8424-24FH	1 ½	2 ¼	1 21/64	10,000	2,500

MALE JIC-37°



Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12MH	¾	1 7/16	19/32	20,000	5,000
8416-16MH	1	1 ¾	25/32	16,000	4,000
8420-20MH	1 ¼	2	1 3/64	12,000	3,000
8424-24MH	1 ½	2 ¼	1 21/64	10,000	2,500

Eastman *first in the field*

MANUFACTURING COMPANY
Dept. MD-5,
MANITOWOC, WISCONSIN

WRITE today for your copies—

Technical Bulletin 100—Medium Pressure Hose and Tube Assemblies, Couplings and Fittings for One Wire Braid Hose.

Technical Bulletin 200—High Pressure Hose and Tube Assemblies, Couplings and Fittings for Multiple Wire Braid Hose.

Circle 444 on Page 19

Another new application for **TITANIUM**

PUMPING HIGHLY CORROSIVE SOLUTIONS?

Titanium provides the answer in "Durcopumps"®

The Duriron Co., Inc., designers and manufacturers of equipment for corrosive service, is among the first to take advantage of titanium's outstanding corrosion resistance in pumps and pump parts.

Working closely with Duriron engineers, Mallory-Sharon helped develop welding and forming techniques for production of a fabricated titanium centrifugal pump. Durcopumps, *with all wet end parts fabricated of Mallory-Sharon commercially pure titanium*, are being produced to order, for pumping hot nitric acids, hot chlorides, etc.

As proof of titanium's superior corrosion resistance, operation of a million-dollar chemical plant was being held up for lack of a suitable pump to handle boiling 65% nitric acid. Cost of downtime was $1,000 per day. Two titanium centrifugal pumps were installed in the line. To date, they have given *over 12 months' service*—compared to less than 30 days' service for nickel-base alloys previously used.

Mallory-Sharon engineers are ready to work with *you* in applying titanium. Write for Technical Data Sheet on *"Titanium Pumps for Chemical Service"*. Please address: Commercial Market Development, Dept. B, Mallory-Sharon Metals Corporation, Niles, Ohio.

MALLORY SHARON

MALLORY-SHARON METALS CORPORATION · NILES, OHIO

Integrated producer of Titanium · Zirconium · Special Metals

Circle 445 on Page 19

"Customeered" components basic to industry

ideas on "Customeered" RUBBER PARTS

...their design and application for improved product performance **No. 1**

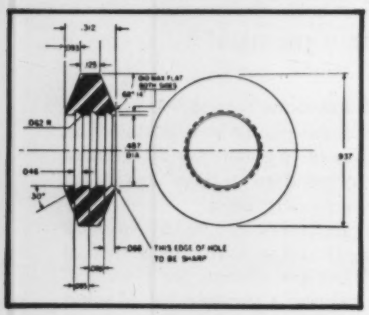
New ORCO continuous process now custom molds precision rubber parts in volume—at less cost!

Precise tolerances within ±0.003 in. are now possible in large volume production of custom-molded rubber component parts. Ohio Rubber's new high-speed, continuous molding process produces such parts at rates of up to 200,000 pieces per day.

Greater precision, which results in important savings on finishing costs, is assured through use of single-cavity, self-registering molds. They permit accurate, uniform application of pressure to minimize flash—maintain consistent tolerances for all dimensions. Uniform material thickness is equally assured by a plasticizing mill, which as an integrated part of the process directs uniform charges to each mold.

Direct feeding, from the mill to the mold wheel, eliminates the conventional intermediate extrusion step and further insures part uniformity and quality consistent with specifications. The continuous process permits *precise* control of time and temperature for each part.

Wide range of parts being more economically produced through Ohio Rubber's new molding process include (top, left to right): valve stem deflector, condenser seal, (bottom) seal piston rod packing, universal joint seal, and oil seal. These, like all the many other small, precision parts already produced or being produced, vary in dimensions up to 1½" in diameter and 1" in thickness.



High-precision is indicated in the close tolerances of this quadruple-landed seal for auto shock absorbers—more economically produced in volume through Ohio Rubber's new high-speed, continuous molding process.

Large volume production results in substantial cost savings for small, precision parts requiring tolerances obtainable by other precision molding processes. For parts formed by less precise, conventional methods, performance can be improved through greater accuracy—and without prohibitive increase in cost.

Quantity requirements involving 500,000 or more parts annually are recommended for most advantageous use of the new process. Since two similar parts of different size can be produced simultaneously by alternating the molds on the molding wheel, lower production runs which might not be economical can be combined with a separate order.

Complete information on this revolutionary new process is available in bulletin form. Send for your free copy today. At the same time, be sure to inquire about Ohio Rubber's complete component "Customeering" service—molding, extruding, and bonding-to-metal. Just mention ORCO Bulletin 715.

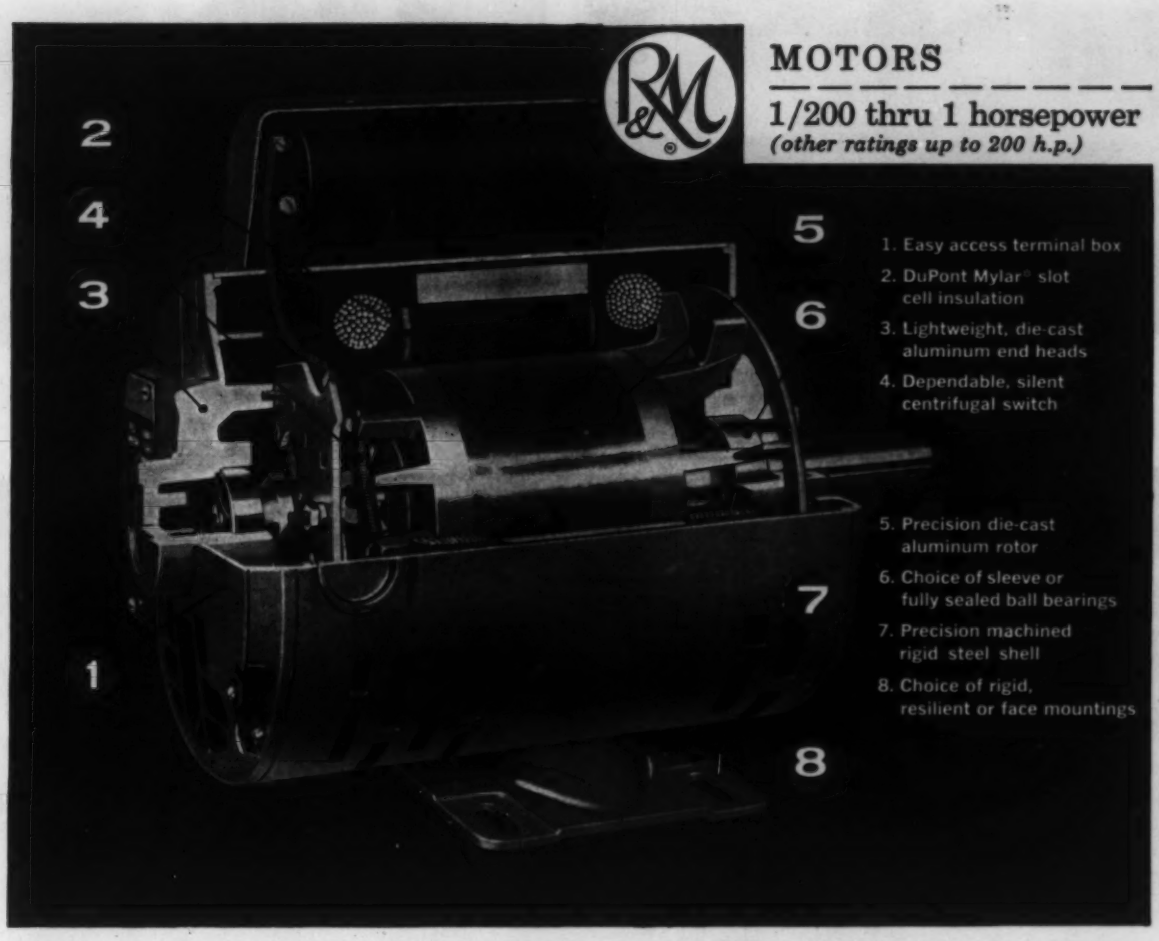
9DE1

THE OHIO RUBBER COMPANY

WILLOUGHBY, OHIO

A DIVISION OF THE EAGLE-PICHER COMPANY

Circle 446 on Page 19



R & M Fractional Horsepower Motors are packed with *Competitive Advantages* for your product!

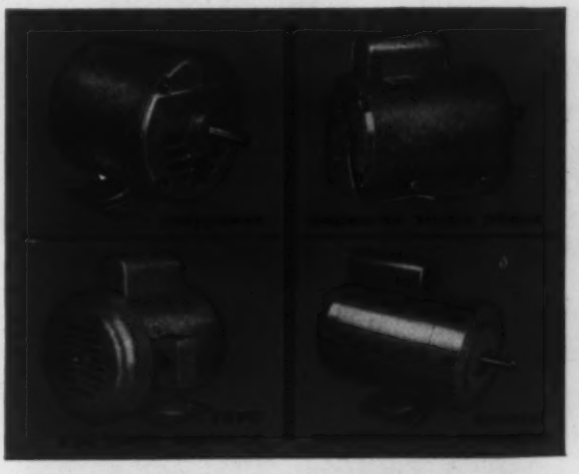
ROBBINS & MYERS "Model R" fractional HP motors, available in NEMA frames 56 and 48, are engineered and manufactured to give your product every possible competitive advantage so far as power is concerned. Each design detail results in superior performance and long trouble-free life, even under the severest operating conditions. They are smaller due to a more efficient ventilating system and lighter because of new applications of aluminum, steel and copper.

You have wider design versatility too, because they are available off-the-shelf in a broad choice of bearings, mountings, ratings, speeds and electrical characteristics.

These up-to-date design features, coupled with careful quality control at each manufacturing step, give you a modern motor you can rely on for all your powering needs. Also, if your needs indicate a custom designed motor Robbins & Myers welcomes the opportunity to discuss your quantity requirements.

Learn all about the many advantages R&M motors offer you by writing today for Bulletin 450 MD

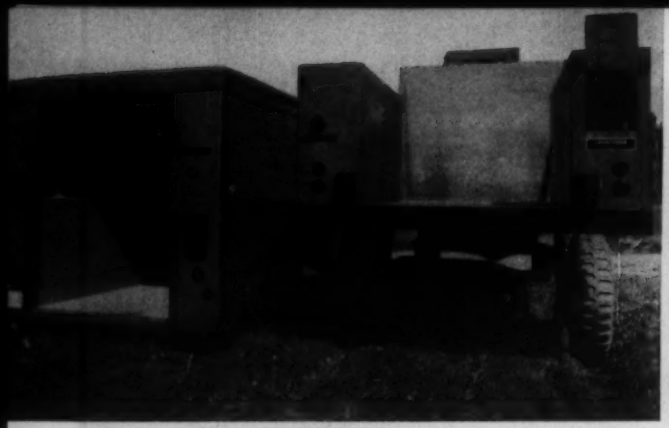
**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO



The Thompson Level-Loder raises and lowers to any height from curb side to 4½ feet. Hydraulic cylinders lift the body up and down in a vertical guide mounted on the truck cab. Thompson Trailer Corp., Pikesville, Maryland, a subsidiary of General American Transportation Corp., Chicago, introduced the new design.

It tilts . .

. . it leans . . . . . it hunches up and down

Unique truck built lighter, stronger with USS COR-TEN Steel

Here's a truck body that acts like an elevator. With front wheel drive, it has no rear axle or drive shaft. Hydraulic cylinders tilt it forward, backward, sideways, and raise it up and down to any height from curb level to 4½ feet. This cuts loading time as much as 75% and makes unloading up to five times faster.

Because the main stress of the lift is concentrated at the wheel box housings, they have to be as strong as possible. And because the truck body is lifted along with the payload, the body has to be as light as possible. The entire body, including the wheel housings, was built with USS COR-TEN High-Strength Low-Alloy Steel because this grade meets the demands of both lightness and high strength. COR-TEN Steel's 50% higher yield point means it can be used in thinner and lighter gages, reducing weight as much as ⅓ with no sacrifice in strength. And it has high resistance to abrasion, atmospheric corrosion, impact and fatigue.

U. S. Steel produces three brands of High Strength Steel—COR-TEN, TRI-TEN, and MAN-TEN. Each has characteristics that make it ideal for special design applications. For complete information about these "steels that do more", write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. *USS, COR-TEN, TRI-TEN and MAN-TEN are registered trademarks*

USS

United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Atlas missile test tower

MISSILE LAUNCHING VALVE COST REDUCED 30% WITH ESCO CASTING

Problem: Fabricating high pressure gas tank butterfly valve bodies for missile component manufacturer Convair-Astronautics, San Diego, California, proved unsatisfactory. Consisting of wrought stainless steel flanges and tubes welded together and machined, valve costs were high. Weld seams were susceptible to intergranular corrosion and gas leakage. This was a critical installation as these units had to withstand test temperatures ranging from −65° to 500° F., at 2,000 vibrations per second and at stresses up to 15 gravity units.

Solution: The valve body was redesigned as a casting. One-piece design alloy steel improved strength and corrosion resistance and practically eliminated the danger of gas leakage. *ESCO* centrifugal casting technique permitted casting six 180-pound valve bodies simultaneously. Resulting savings in material and labor amounted to 30 per cent of previous costs.

You can simplify your design problems by calling an ESCO engineer today.

ESCO®

ELECTRIC STEEL FOUNDRY COMPANY

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MFG. PLANTS AT PORTLAND, ORE. AND DANVILLE, ILL.
Offices in Most Principal Cities
ESCO INTERNATIONAL, NEW YORK, N. Y.
IN CANADA ESCO LIMITED

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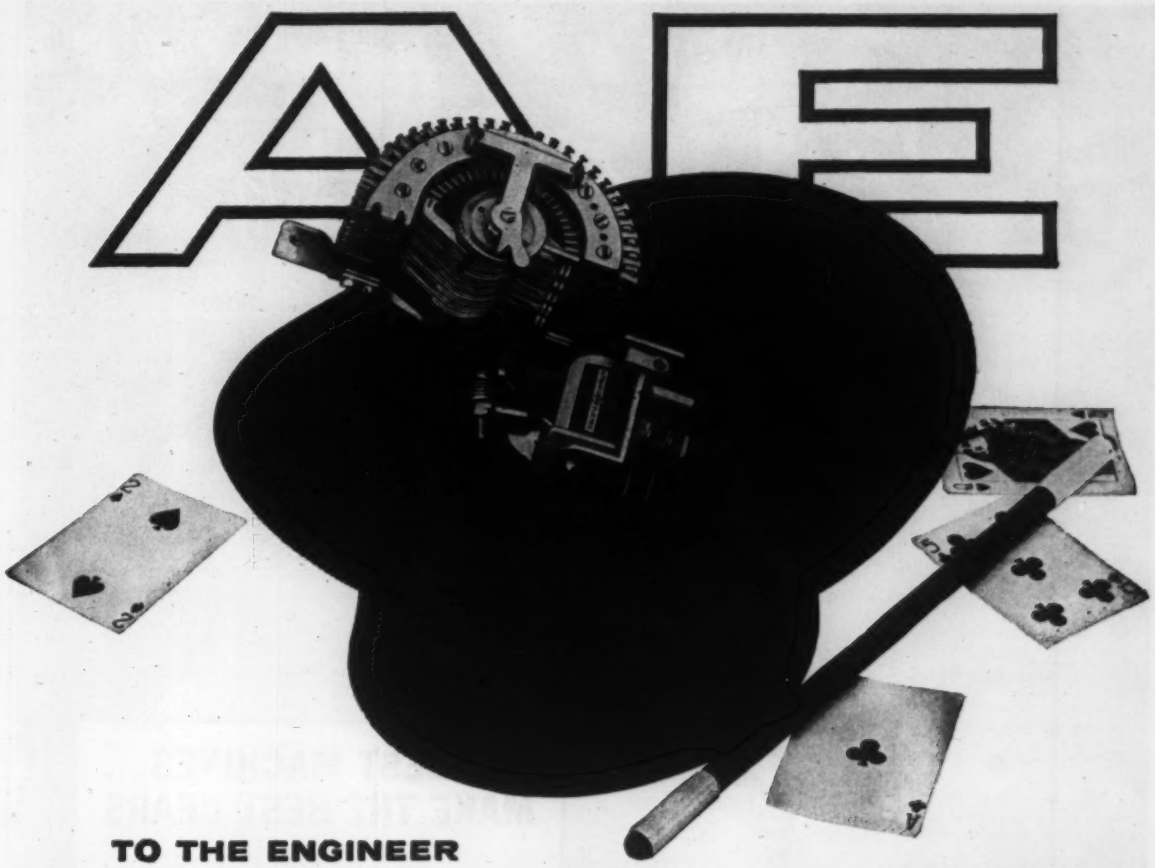

TO THE ENGINEER

who can use a little honest trickery

There's more than one way of skinning a cat —or making ideas *work* automatically. And AE has a bag-full.

That's because AE has had years of experience in making relays and stepping switches work wonders in automatic telephone exchanges—*and* in automatic control devices.

If you can use some down-to-earth magic in your designs, AE engineers will be glad to help. And you may well find that their suggestions can simplify the control package.

They can also show you why AE relays and stepping switches cost you less in the long run.

For instance, the AE Type 45 Stepping Switch, illustrated, has a free-floating pawl that never binds, never breaks, eliminates the necessity of ever readjusting armature stroke, does away with double-stepping or overthrow. And the switch usually outlasts the equipment it's built into!

You'll also be interested in knowing that AE is equipped to deliver completely wired and assembled control units designed to your specifications.

Want more information? Just write the Director, Industrial Products Engineering, Automatic Electric, Northlake, Illinois. Ask for Circular 1698-H: *Rotary Stepping Switches;* Circular 1702-E: *Relays for Industry;* and our new 32-page booklet on *Basic Circuits.*

AUTOMATIC ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

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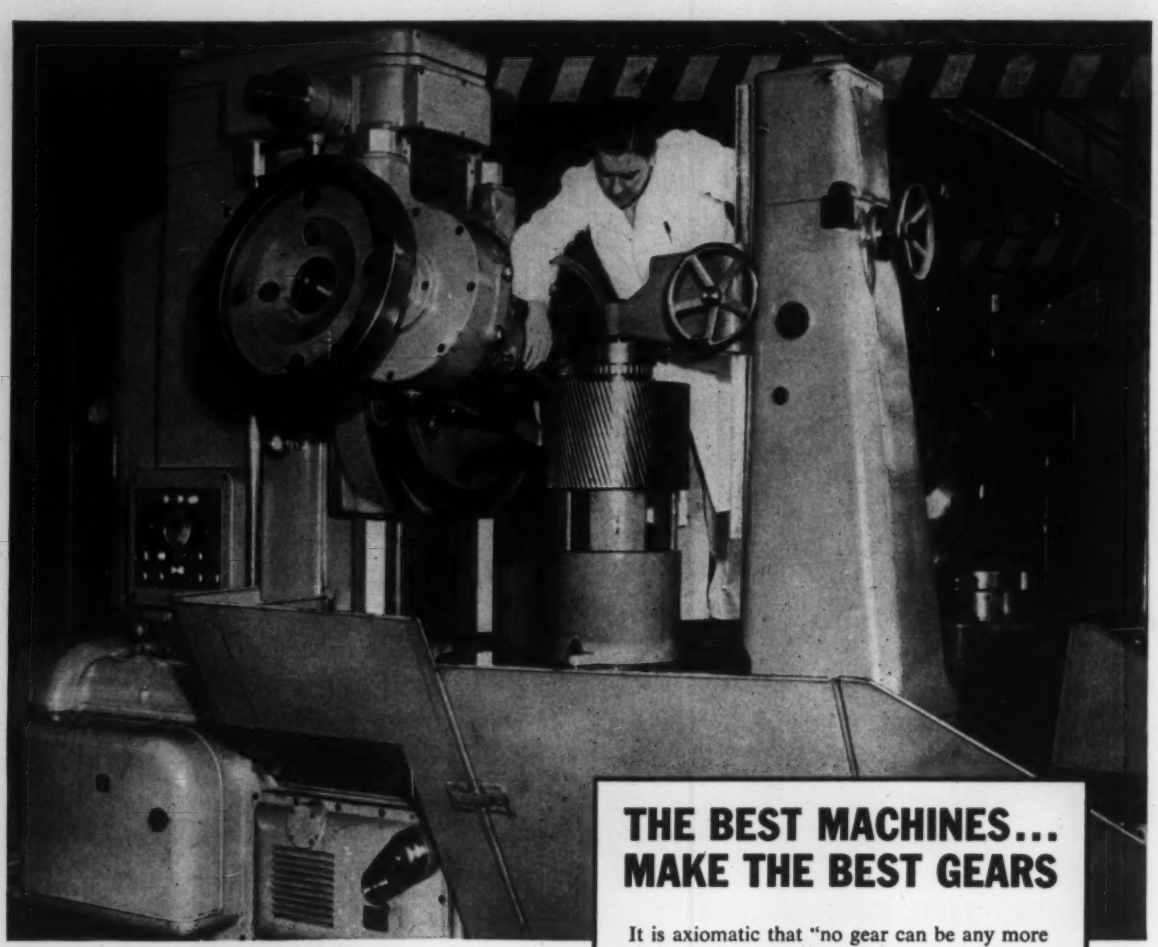
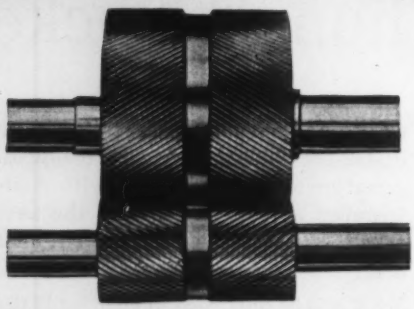


THE BEST MACHINES... MAKE THE BEST GEARS

It is axiomatic that "no gear can be any more accurate than the machine on which it is made" . . . to this end we have continually installed the most modern and accurate gear machinery for producing all types and sizes of gearing . . . these machines are operated by skilled gear craftsmen . . . but even this is not enough at Phillie Gear, for all gears must be checked and analyzed on the latest testing machines. *There's no compromising with Quality at Phillie Gear.*

Indicative of the standard of precision required of our manufacturing equipment is the gear hobber shown above. This machine has a special high accuracy table drive which is maintained accurate within 20 arc seconds. This accuracy is significant in consideration of the fact there are 1,290,000 arc seconds in a circle.

When you think of gears—think of Phillie Gear. Write for a free copy of our 76 Page Gear Book—a complete data book on all types of gears.



A set of large opposed Helical Gears and Pinions made for a high speed, single reduction drive . . . gears are carefully finished shaved for quiet operation. Philadelphia now has ultra precision facilities for tooth grinding up to 72" in diameter.

OTHER PHILADELPHIA GEARS:

SPUR • HELICAL • SPUR INTERNAL • HELICAL INTERNAL • RACK • HERRINGBONE • WORM • NON-METALLIC • SPLINES • CONIFLEX BEVEL • SPIRAL BEVEL • ZEROL • HYPOID • INTERMITTENT • SPROCKETS • CONTRACT MACHINE WORK

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PHILADELPHIA GEAR CORPORATION

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Offices in all Principal Cities

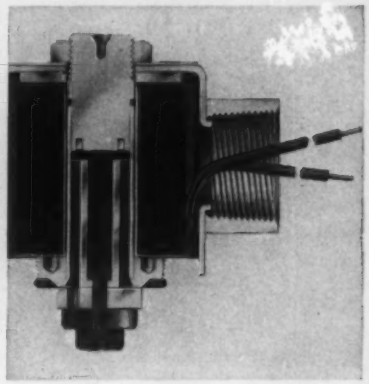
INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

Virginia Gear & Machine Corp. • Lynchburg, Va.

Circle 450 on Page 19

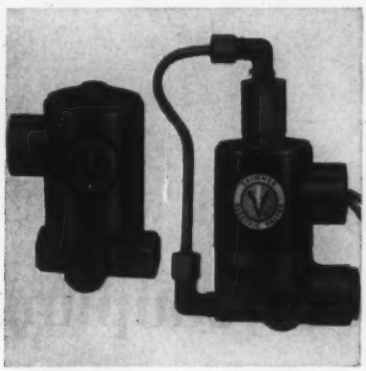
Skinner introduces Two-Way Solenoid Valve for Control of High Pressures

New High Pressure Models just added to the Skinner two-way Type R series line of pilot-operated solenoid valves are offered in two-way normally closed construction only. Orifice size is ¼" diameter with ¼" NPT ports. Operating pressure differentials: 5 to 1250 psi on AC voltages and 5 to 1000 psi on DC voltages. Designed for use with such media as air, oil, water and semi-corrosive liquids.

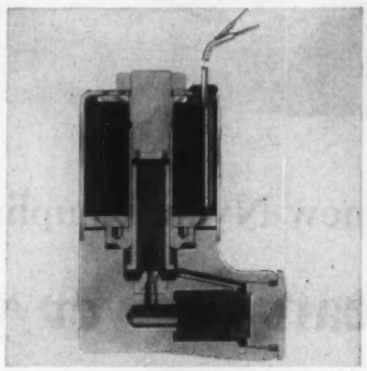


Features. New Skinner Models are built to U. L. requirements in standard and explosion-proof construction. V5-2H type solenoid operator contains stainless steel internal parts to resist corrosion. Valve body is forged naval brass and contains stainless-steel piston assembly, precision machined to close tolerances for positive opening and closing of the main orifice.

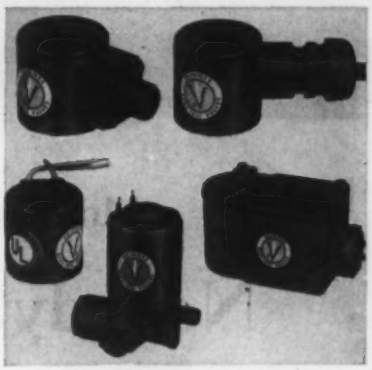
Variety of Coil Voltages. Standard coils, built to U. L. standards, are varnish-impregnated and moisture-resistant. Molded waterproof coils are available that will even operate under water and are resistant to fungus growth. Coils are available in wide range of voltages and frequencies.



Standard Pressure Two-way R Series Valves. These two-way valves are available in standard and explosion-proof construction, normally open or normally closed. Pressure operating differentials are 5 to 200 psi for normally closed and 5 to 150 psi for normally open.



Many Desirable Features: Standard pressure R series two-way valves have V5 type operator; stainless steel internal parts; naval brass body; stainless-steel piston assembly; soft synthetic inserts for bubbletight operation. Normally open models have piped-body return. Valve can be mounted in any position.



Custom Installation with these Options. There is a large selection of electrical housings that can be rotated 360° for easy connecting. Also available is manual override that permits opening or closing the valve in the event of current failure.

Skinner Solenoid Valves are distributed nationally.

For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at Dept. 425.

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

THE SKINNER ELECTRIC VALVE DIVISION • NEW BRITAIN, CONNECTICUT

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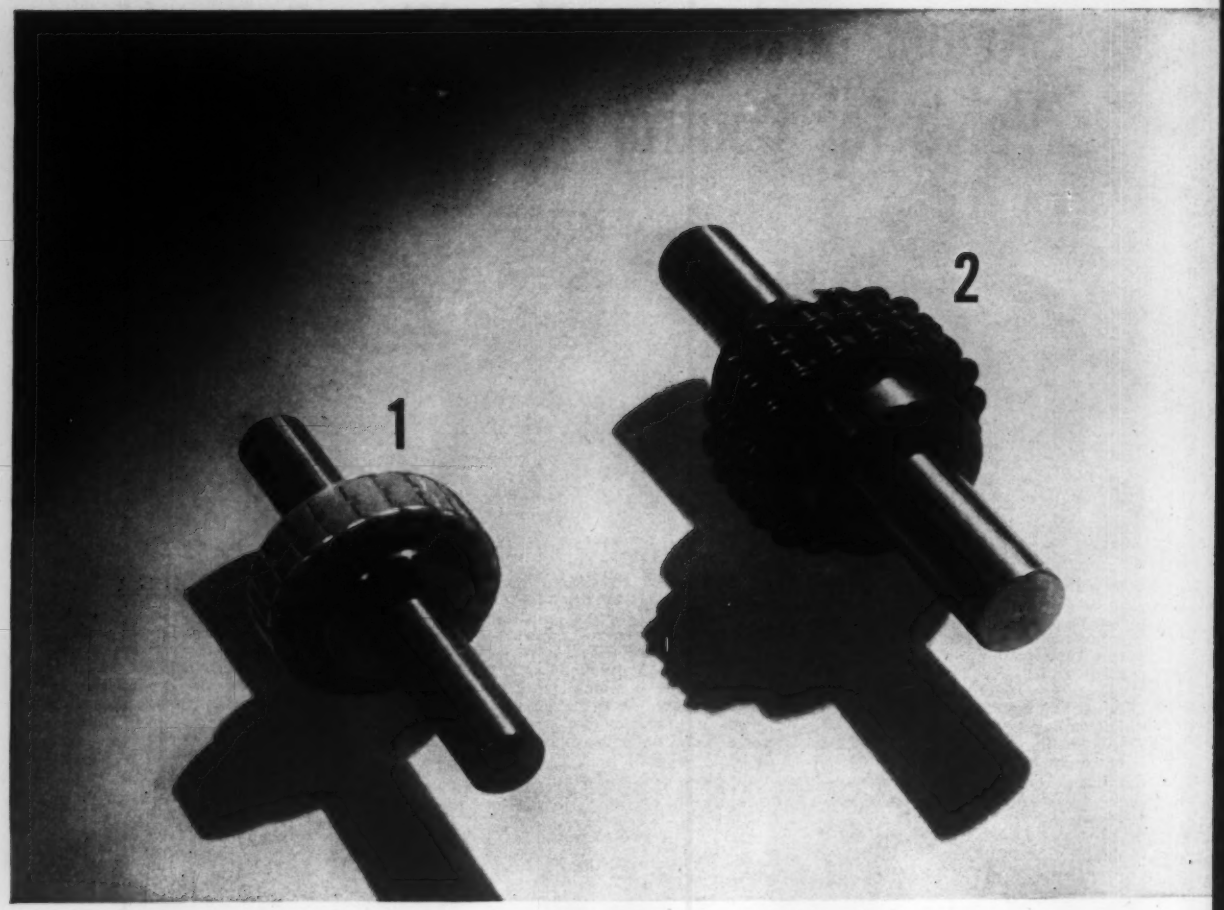


Morse's new Nylon Coupling means:

Nobody can answer your coupling because only Morse offers

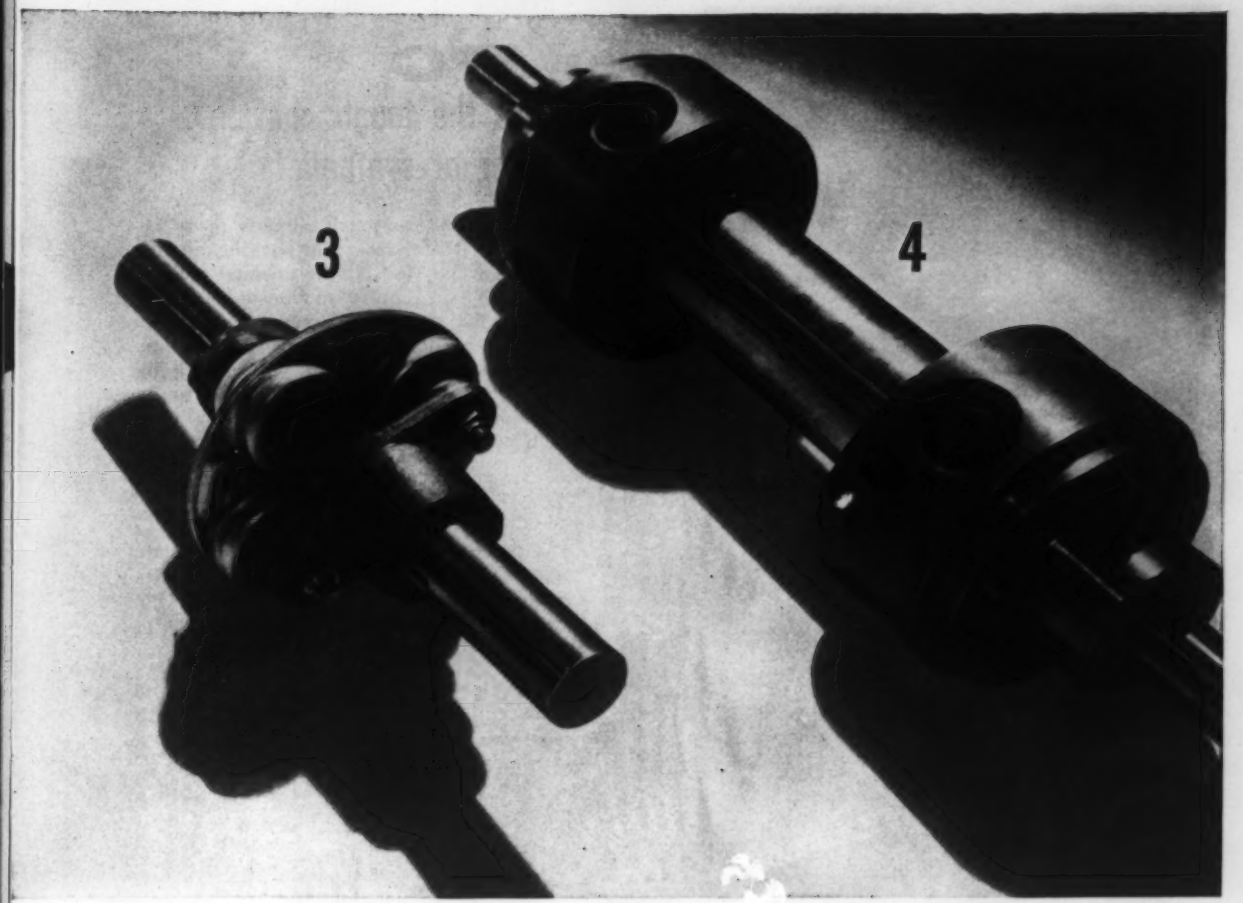
1 New Nylon Couplings:
Cost 20% less than conventional couplings; last indefinitely. Need no lubrication, no cover; take high torque; adjust to misalignment.

2 Flexible Chain Couplings:
For moderate speeds, steady loads. Rugged, economical . . . take higher h.p. per given diameter. Easy to install, align, and disassemble.

3 Morflex Couplings:
Preloaded neoprene biscuit assembly reduces misalignment stresses, increases bearing life; protects machine from shock and vibration.

4 Radial Couplings:
Neoprene biscuits—assembled radially on pins—take heavy thrusts, torques, shocks, frequent load reversals; retain torsional flexibility.

NOTE: All Morse couplings are available in driveshaft constructions.



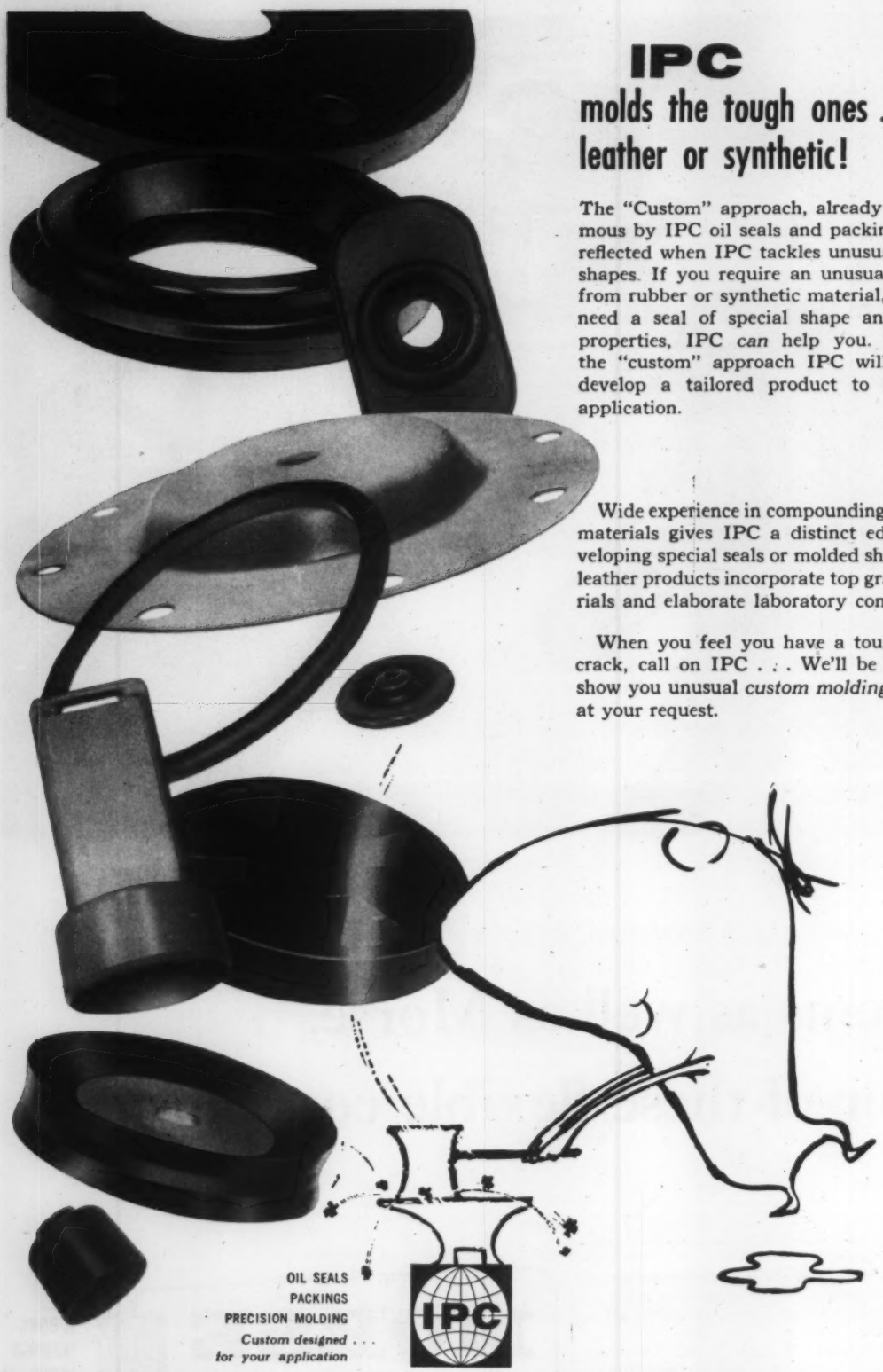
problems as well as Morse, all four of these flexible couplings

REMEMBER: Nobody gives you a more *impartial* analysis of your power transmission problems than Morse, because *only Morse* offers all four of these basic drives: Roller Chain, Silent Chain, Hy-Vo®, and "Timing"® Belt Drives . . . plus a complete line of power transmission products.

MORSE MORSE B-W *Trademark

* A BORG-WARNER INDUSTRY

MORSE CHAIN COMPANY, Dept. B-58, ITHACA, NEW YORK. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.



IPC
molds the tough ones . . . leather or synthetic!

The "Custom" approach, already made famous by IPC oil seals and packings is *also* reflected when IPC tackles unusual molded shapes. If you require an unusual molding from rubber or synthetic material, *or* if you need a seal of special shape and specific properties, IPC *can* help you. By using the "custom" approach IPC will actually develop a tailored product to suit your application.

Wide experience in compounding synthetic materials gives IPC a distinct edge in developing special seals or molded shapes. IPC leather products incorporate top grade materials and elaborate laboratory control.

When you feel you have a tough nut to crack, call on IPC . . . We'll be happy to show you unusual *custom molding* samples, at your request.

OIL SEALS
PACKINGS
PRECISION MOLDING
Custom designed . . . for your application

IPC

INTERNATIONAL PACKINGS CORPORATION
Bristol, New Hampshire

P3

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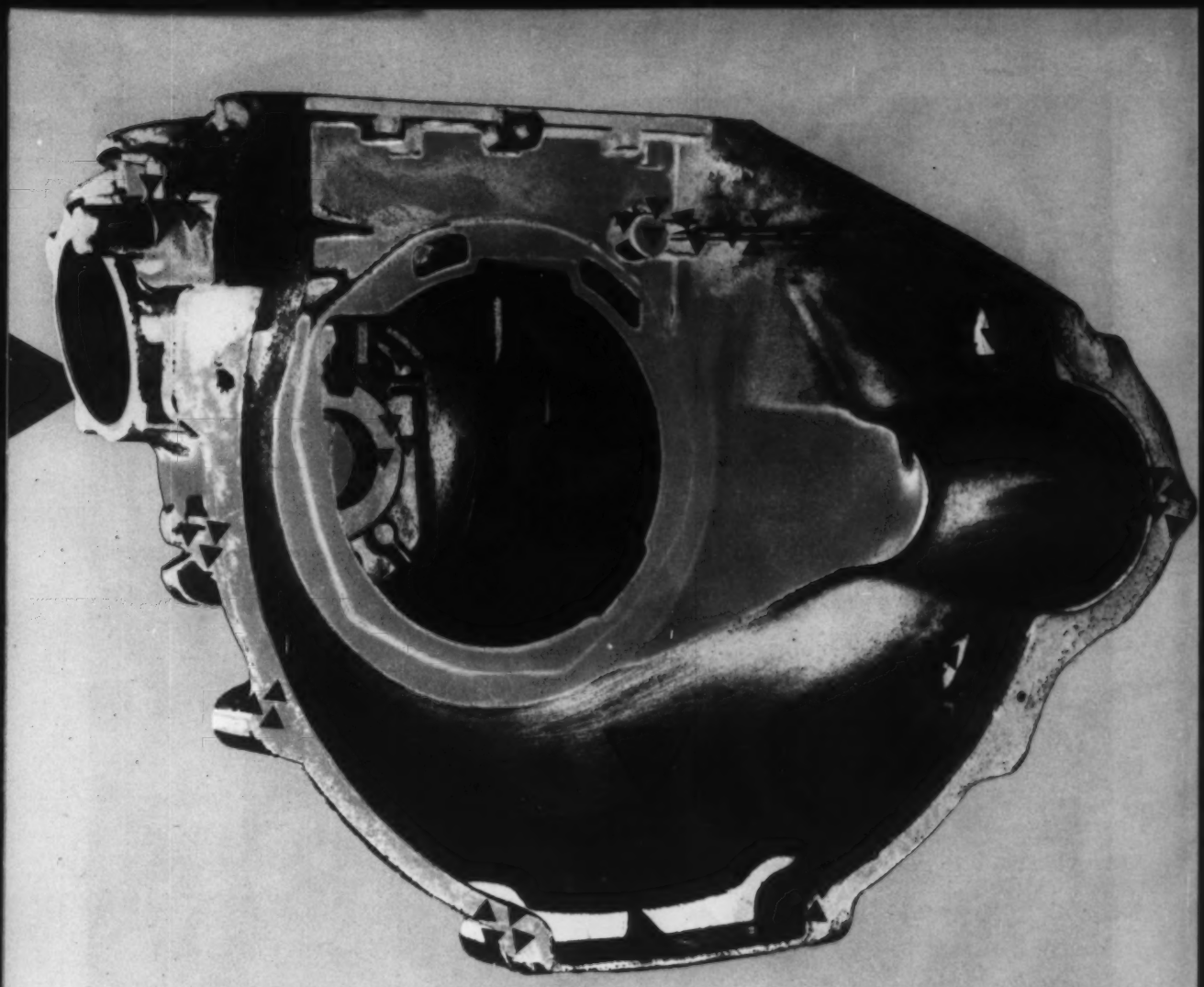
Circle 454 on Page 19→



in
castings...

Alcoa puts the metal where you want it

The design areas in this permanent-mold casting are pegged in red. The part itself is an automatic transmission housing for the '59 Ford car. It weighs 24 lb, 61 lb less than its cast-iron predecessor. The cyclone forces that whirl through modern automatic transmissions bring stress ranges in some parts of the casting up to 21,000 psi. The problem was to provide adequate strength without unnecessary weight in the casting walls.

Alcoa was not only able to offer a complete test facility, but was able to offer some sound design tips, too. Stresscoat and strain gage tests revealed the areas where special design attention was necessary. We were able to produce the parts to meet the exacting production schedule of the automotive industry.

In castings as well as forgings, screw machine parts, extrusions and impacts, Alcoa puts the metal where you want it. To you, this may mean fewer rejects, or it could provide the key to ingenious solutions for difficult design problems. Start now; write for Alcoa's Up-To-Dater, a starter file of ideas and design tips on Alcoa Engineered Products. Aluminum Company of America, 917 Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM

Alcoa puts the metal where you want it—in castings, forgings, impacts, extrusions and machined parts.

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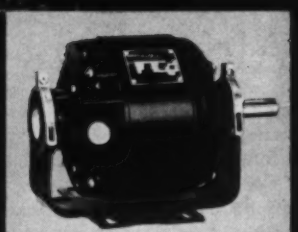
"STRESS AREAS"

A fine racing car must be *precision-designed* and *precision-built* . . . as must the motors for your appliance or equipment applications. At Emerson-Electric, you get the benefits of more than 65 years of experience in solving motor-drive problems . . . plus unique production facilities that produce *in volume* the precision motor specifically designed for *you*.

Remember . . .

- Emerson-Electric has more than 100 skilled engineers ready to offer you on-the-spot service from design right on through application tests.
- Emerson-Electric produces *custom-engineered* motors to suit *your specific needs*.



To solve your motor-drive problems with precision, call, wire or write Dept. M373 today. The Emerson Electric Mfg. Co., St. Louis 21, Mo.

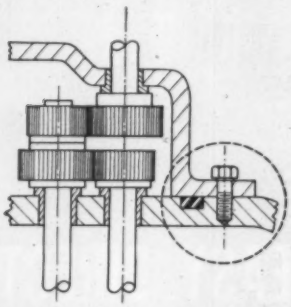
EMERSON-ELECTRIC *of St. Louis · Since 1890*

Technical data for gasket design and selection

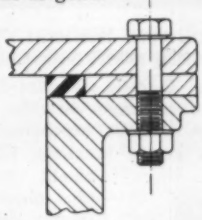
Effective sealing with confined gaskets

To seal a metal-to-metal joint effectively, a gasket must completely fill the gasket channel to provide maximum contact with the mating flange . . . and it must compress enough to prevent leakage of the sealed medium.

With truly compressible materials, such as cork-and-rubber composition, gaskets are cut to full channel width, and from 1.25 to 1.5 times channel depth. No relief for sideflow is needed, and close tolerances for gasket and metal are unnecessary.



In Figure 1, the instrument housing flange employs a completely confined cork-and-rubber gasket that prevents lubricant leakage and permits perfect alignment of gears.



In Figure 2, an annular shim adapts flat flanges to metal-to-metal sealing. Cork-and-rubber gasket compresses to form a tight seal without flowing out.

Send for a copy of the new Armstrong Gasket Design Manual. Write on your business letterhead to Armstrong Cork Company, 7105 Dean Street, Lancaster, Pennsylvania.

Engineering research on aluminum flanges shows how bolt torque loss can be reduced

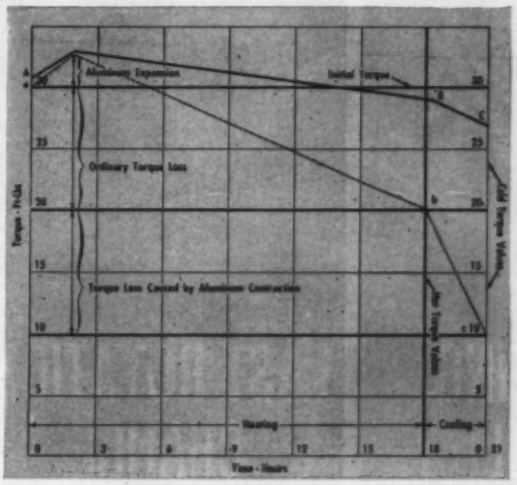
Alternate cycles of heat and cold often cause serious loss of bolt torque on aluminum flanges.

To study this problem, Armstrong engineers set up simulated service tests with stock automotive transmission housings. These housings all have large aluminum members that are subject to wide variations in temperature, and all require high flange pressures.

The initial result of the tests indicated—as expected—that the expansion of the aluminum had the effect of substantially increasing the unit load on the gasket. The consequent crushing and extruding of the conventional fiber gaskets led to loss of bolt torque.

The study also turned up other data unique to aluminum flanges. This is the difference between "hot" torque readings—taken while the transmission is at 300° F.; and "cold" readings, taken after the assembly cools. With iron or steel flanges, there is no significant difference between these readings. With aluminum, however, the difference often is 20% or more.

The difference between "hot" and "cold" torque readings is a measure of the ability of a gasket to "follow" the flange as it undergoes dimensional change. Ideally, a gasket should show no difference between hot and cold torque readings. It should resist crushing under high pressures and high temperatures—and it should compensate for the contraction of the flange as it cools.



Although high pressure and heat will cause some torque loss with any gasket, it is obviously important to keep such loss at a minimum. Test results on this chart were obtained from transmission housing heated to 300° F., then allowed to cool. The dotted line represents average test results with conventional gaskets. Note difference in torque values (b & c) compared to initial torque (a). The solid line is an average result of tests with Accopac AN-890. Note that hot and cold torque readings (B & C) are very close to initial torque value (A).

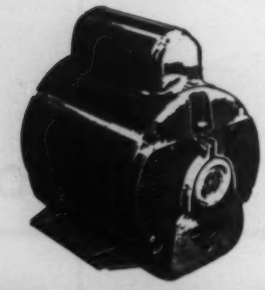
Because conventional materials fall short of these requirements, Armstrong engineers set out to develop a new type of gasket. Their work resulted in a new beater-saturated asbestos material—Accopac AN-890. This new gasket resists crushing under pressures of 100,000 psi at temperatures up to 350° F., and it has superior torque retention characteristics.

Our research on aluminum flanges may be useful to you. We will be glad to make suggestions if you will send details of your problem to us.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

Circle 456 on Page 19



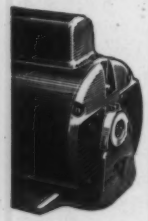
DESIGN ENGINEERS...

SIX WAYS

MOUNTING VERSATILITY

Cradle bases, both solid and resilient, allow rotation within base

You can rotate the Form G motor within the cradle base to take advantage of its drip-proof design, or you can position the motor with the capacitor at various angles for tight-squeeze applications. Or, you can remove the cradle base if you don't need it for your application. G-E Form G mounting versatility can mean greater design flexibility for you!

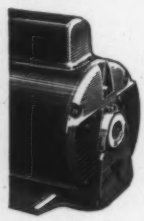


GENERAL ELECTRIC

FAST ROTATION CHANGE

Now you can reverse Form G shaft rotation in less than 10 seconds

No need to specially order motors to meet your rotation requirements. G.E.'s Form G motor features a new wiring method that lets you change rotation in seconds. Quick connectors make the change fast and positive. Just interchange the two motor leads on the terminal board. That's all. Require fast, easy rotation change? The Form G is your motor!

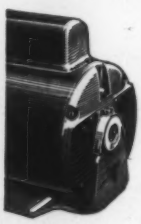


GENERAL ELECTRIC

EASY, DIRECT MOUNTING

Close end shield tolerances allow direct mounting without costly machining

General Electric standard Form G's can be mounted directly on your product without expensive machining or costly brackets. Close end shield tolerances, plus inherent shaft-to-end shield concentricity, lets you mount General Electric's Form G's with simple through bolts. This feature could be a real money saver for you. Why not investigate it today?

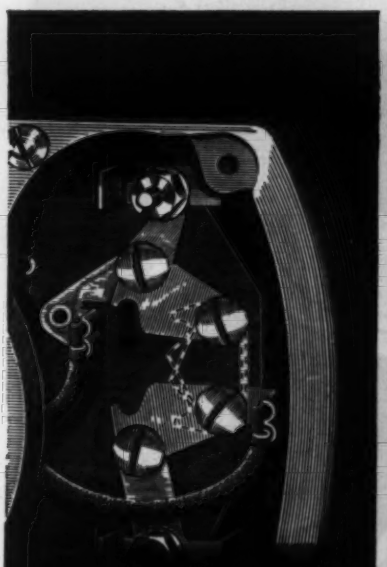


GENERAL ELECTRIC

JUST ASK YOUR GENERAL ELECTRIC SALES ENGINEER

Cut costs with General Electric Form G motors...

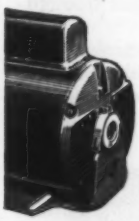
MORE VERSATILE



FAST VOLTAGE CHANGE

Unique sliding plates on terminal boards make voltage change simple

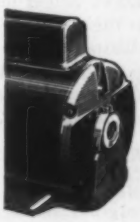
Reduce inventory, simplify ordering! You can change General Electric Form G motors from 115 v to 230 v operation (or vice versa) in 1/5th the time, without confusion and error. No special tools required! A screwdriver is all you need. Just loosen the four screws, pivot the plates to the new position and tighten the screws. That's all there is to it!



ALL-ANGLE OPERATION

Special bearing and oil retention system permits mounting in any position

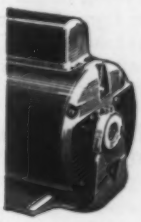
Mount it horizontally, vertically—even upside-down—the new Form G has the versatility to match the design and space requirements of your product. An advanced bearing and full oil retention system allows you to mount the Form G in *any* position and still be sure of getting faithful motor performance. In any position, Form G's do the job!



COMPLETE LINE

Full line of Form G's means the right motor for every application

There's a standard Form G motor to meet your exact product requirements. No need for costly specials. Over 850 basic models—and thousands of variations—are available on a mass-production basis. Let your General Electric Sales Engineer show you the all-around versatility of Form G motors and how they can provide important savings for you!

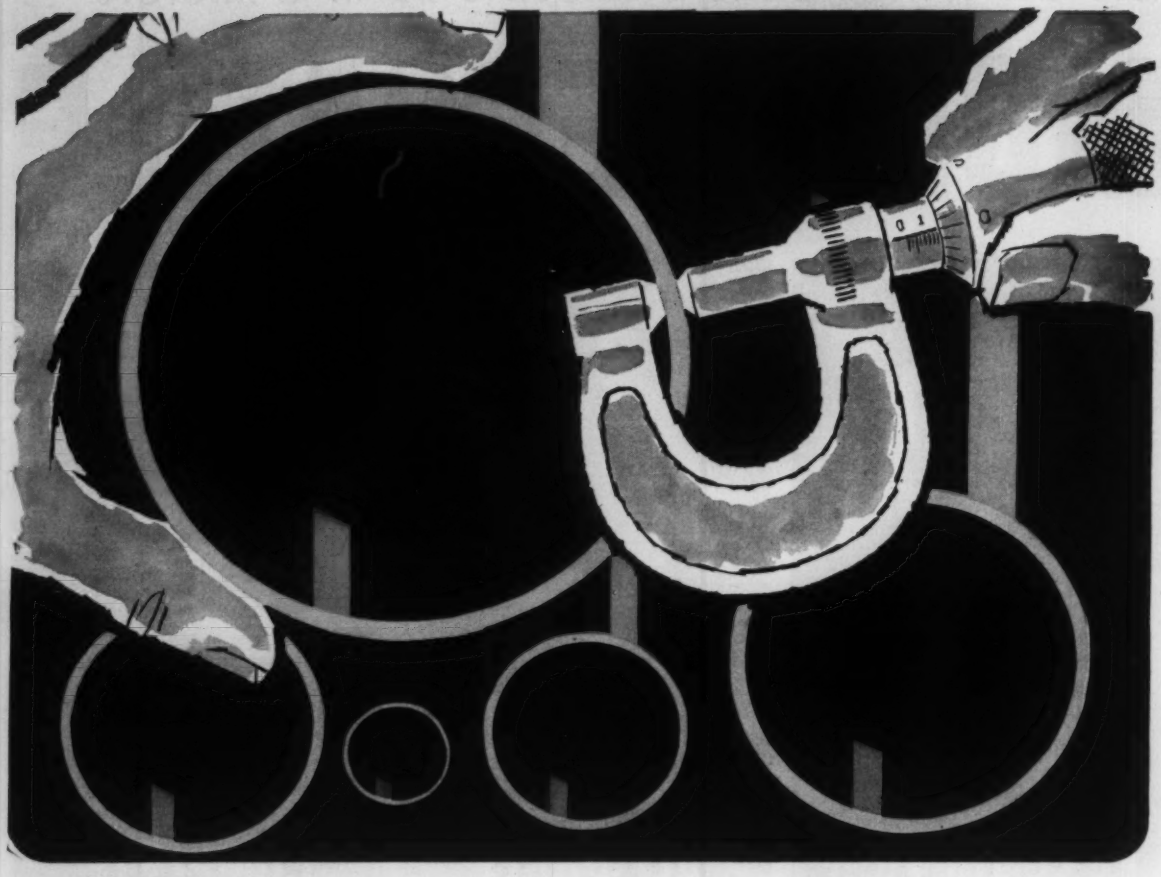


702-92

GENERAL ELECTRIC GENERAL ELECTRIC GENERAL ELECTRIC

ABOUT THE NEW FORM G "EXTRA VALUE" FEATURES

Experience *— the added alloy in* ***Allegheny Stainless***



looking for thin walls in big diameters?

A-L now offers a wide range of stainless seamless tubing with walls as thin as .013".

From what other source would you expect to get stainless seamless tubing of 3½" OD with walls as thin as .058" and in the widest range of materials anywhere to fit a broad range of requirements in new products and processes?

Allegheny Stainless Tubing ranges for 3/16" OD to 3½" OD with wall thickness from .013" to .375". Typical of the specials A-L can make are 2½" OD—.032" wall thickness, 3" OD—.042" wall thickness and 3½" OD—.058" wall thickness. All sizes with true circularity, no dents or handling marks.

Stainless seamless tubing is made in all stainless grades including 309, 317, 318, 310, 416 and 446—normally difficult to obtain. For special high-temperature applications, A-L produces tubing in high-strength alloys such as A-286, and in vacuum melted steels and alloys. Also in custom analyses such as low cobalt (.01-.05) grades and with boron additions to standard grades.

A-L also makes composite tubes with bonded combinations of carbon and stainless steels and other metals for unusual corrosion applications in process equipment.

Allegheny Ludlum Tubing is available in small orders in random or cut lengths. Standard grades in stock throughout the country.

Write for your copy of Allegheny Ludlum Stainless Tubing, or call your A-L representative for all the help you need. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. MD-17.***

NEW!
FREE—A-L's new book on stainless tubing. 32-pages of technical data, sizes, grades and suggested applications.

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EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

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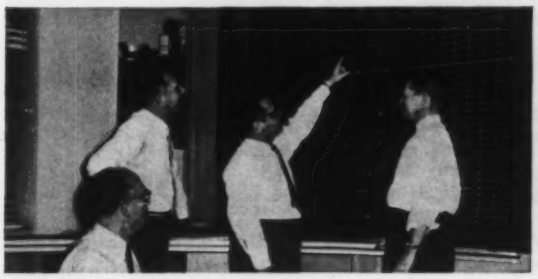
CUSTOM ENGINE BUILDING FOR INDIVIDUAL APPLICATIONS, INCORPORATING SAVINGS OF AUTOMATED PRODUCTION.

Production of Chrysler Industrial Engines has been completely reorganized. Basic engine blocks are machined in the huge Chrysler automated engine plants. Production facilities of the division itself are devoted exclusively to building the finished engine as specified — with any of the thousands of possible combinations of options and accessories. This gives you the advantage of an engine built for your individual application at a price which incorporates automated production savings.



FASTER PRICING AND DELIVERY WITH LESS LEAD TIME REQUIRED ON ORDERS.

Production and production control is now coordinated under one roof. Production scheduling and follow-up procedures assure you that your orders will be produced to exact specifications and delivered on schedule with a minimum of lead time required. There is not only daily, but hourly, contact between all our departments. Where required, "personalized" follow-through on individual orders is possible and practical.

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FASTER FIELD SERVICE AND PARTS AVAILABILITY THROUGH NEW ENGINE CENTERS, EXPANDED DEALER NETWORK.

New Chrysler Industrial Engine Centers, together with an expanded dealer network, offer even the most remote users of your Chrysler-powered equipment efficient, 24-hour service, plus immediate delivery of replacement parts and engines.

Each engine center has a large and complete inventory of industrial parts and replacement engines available on regular and 24-hour emergency basis, delivered by special service trucks. In addition, each engine center has ample service buildings, tools and trained engine specialists to provide service for all types of Chrysler-powered equipment in the area.

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Better and still better power for your particular application is the goal of our expanded research, development and field-testing program. The more economy, dependability, trouble-free performance we can build into Chrysler Industrial Engines, the more desirable your products are to your customers. In addition to improving present applications, we are particularly eager to work with manufacturers on pilot models to expand the range of Chrysler-powered applications, for we know the success of our product depends upon how well it works for you.

CHRYSLER M I

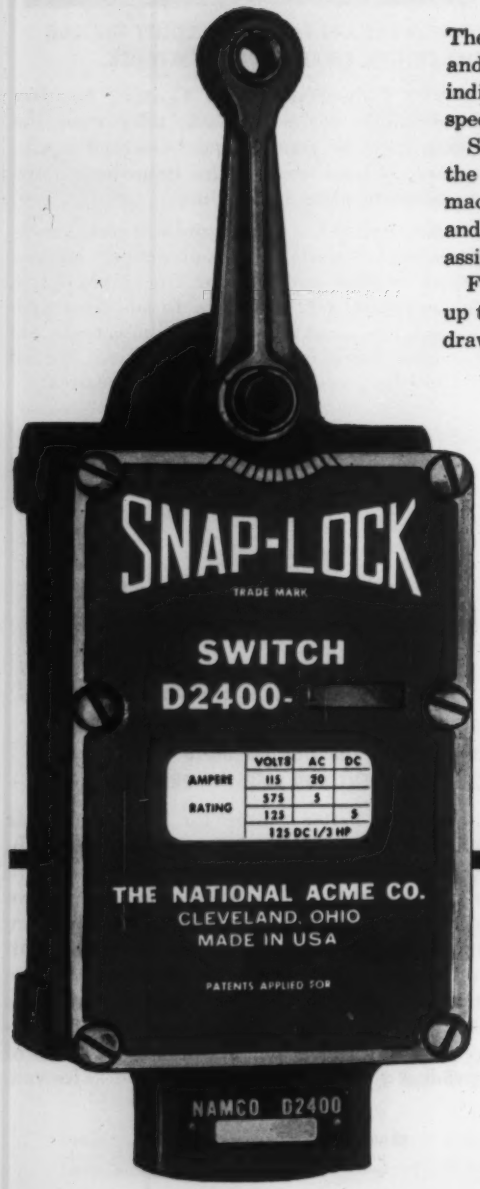
MARINE AND INDUSTRIAL ENGINE DIVISION
CHRYSLER CORPORATION • DETROIT 31, MICHIGAN

● NEW product line catalog helps you "build" and price an engine to fit your specific application — right at your desk. Call or write.

Circle 459 on Page 19

SNAP-LOCK Limit Switches

Actuate Two Circuits Simultaneously ...Without Special Linkage



The D-2400 series Snap-Lock Limit Switches with two normally open and two normally closed contacts permit making or breaking two individual circuits simultaneously. Mounting problems are simplified, special linkages eliminated and costs kept to a minimum.

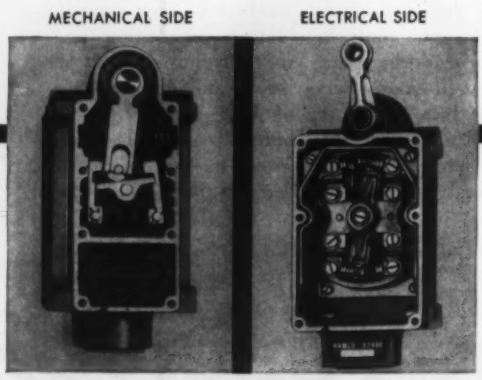
Snap-Lock Limit Switches were originated by National Acme to meet the severe mechanical and electrical conditions imposed by all types of machine tools. The outstanding simplicity and ruggedness of these water and oil tight switches make them adaptable to the toughest heavy-duty assignments.

Four basic models with a wide variety of actuating levers will handle up to 5 amps, 600 volts, AC. For complete details, parts list, and scale drawings, write for Bulletin EM-5824.

National Acme

THE NATIONAL ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N. J., Chicago 6, Ill., Detroit 27, Mich.



All Snap-Lock switches have separate enclosures within a single housing for the mechanical and electrical sides. Ample wiring space is provided and maintenance greatly simplified.

Circle 460 on Page 19

Mammoth parts for Iroquois and other locks in St. Lawrence Seaway and Power Project depend on nickel alloy steels for prolonged service without repair.

Nickel Alloy Steels help open the world's eighth sea to commerce

The opening of the St. Lawrence Seaway turns the Great Lakes into the world's eighth sea—giving us, in effect, a North American counterpart of the Mediterranean.

Man moved water and earth—even towns—to make this possible. It was a colossal job . . . and called for that kind of thinking and building.

Take some of the lock bridge construction, as an example. Cast steel track girders and segment girders for the rolling lift bridge at Iroquois Point, in the International Rapids Section, weigh as much as 14 tons. **Repairing or replacing** such monster units any time after installation would be excessively expensive. And in some locations, practically impossible. So where long life plus high strength and toughness are important considerations, castings of nickel steel are high-ranking favorites. This high strength nickel alloy steel is liberally used wherever the stresses on structural shapes are most severe and where castings are exposed to atmospheric corrosion.

Do you have a metal problem? One involving stress . . . wear . . . corrosion . . . fatigue . . . temperature extremes or other complicating factors? Talk it over with us. We—and Nickel or a Nickel Alloy—may be able to help you find the channel that leads to open water. *Registered trademark

Heavyweights. Segment girders of nickel steel for Iroquois Lock rolling lift bridge weigh 27,000 pounds apiece.

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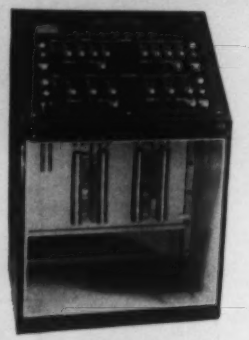
NICKEL MAKES ALLOYS PERFORM BETTER LONGER



Operating console used in automatic control of drying system. Control Panel Corporation also builds the custom-made cabinets.

Motor controller manufactured for the Navy under prime contract. Qty 107. All major operating components meet Navy "A" High Stock requirements. Assembly-line produced on sub-assembly basis.

This panel automatically controls newsprint paper conveyor at three stations. Controls include electric switching of conveyor routes. Entire system governed by interlocking photoelectric safety relays which prevent paper from bunching or running off conveyor terminals.

2 miles of wire in this free standing control panel for controlling "Detroit Type" transfer machine. Constructed to meet JIC Specifications. Used by automotive company in the manufacture of connecting rods. Completely wired and interconnected for checking before taking down for shipping.

Here's where *Reliable, Compact* Automatic Control Panels *Cost You Less!*

Whether it's design *and* assembly—or assembly to your existing design . . . Control Panel Corporation can guarantee reliable, compact control panels at less cost. And we can *meet* your due date.

This is possible simply because panel manufacturing is our *only* business. Our efficiency is high—so your cost is naturally lower. Furthermore, Control Panel Corporation provides the custom-made enclosures you want at prices competitive with ordinary stock enclosures. That's why scores of companies, big and small, keep coming back to Control Panel Corporation.

Best way of showing our potential use to you is by submitting our quotation or proposal covering your requirements—be it one thousand panels or one. There is no obligation, of course.

ASK FOR NEW BULLETIN

Lists Pantro users and Pantro users. Shows a cross-section of the many types of automatic control panels. Pantro has designed or built for industry of all kinds.

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A Partial List of Pantro *Uses:*

- Bakery machinery
- Canning machinery
- Cement and clay working machinery
- Chemical machinery
- Confectionery and ice cream machines
- Construction and road-building machinery
- Flour, grain mill machinery
- Food products machinery, misc.
- Foundry machinery
- Machine tools
- Metalworking machinery
- Oil field machinery and tools
- Paper industries machinery
- Plastics molding machinery
- Printing trades machinery and equipment
- Rubber working machinery
- Special industry machinery
- Textile machinery
- Woodworking machinery
- Conveyors and conveying equipment
- Cranes, hoists, derricks
- Furnaces and ovens, industrial
- Hydraulic equipment, including pumps and controls
- Internal combustion engines
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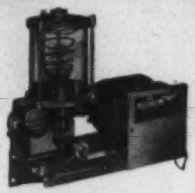
- Locomotives and parts
- Railroad and steel cars and equipment
- Communications equipment
- Electronics equipment
- Motors, generators, motor generator sets

NEW LINCOLN CENTRALIZED LUBRICATION SYSTEMS



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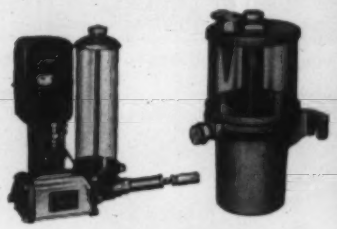

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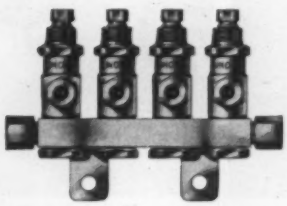
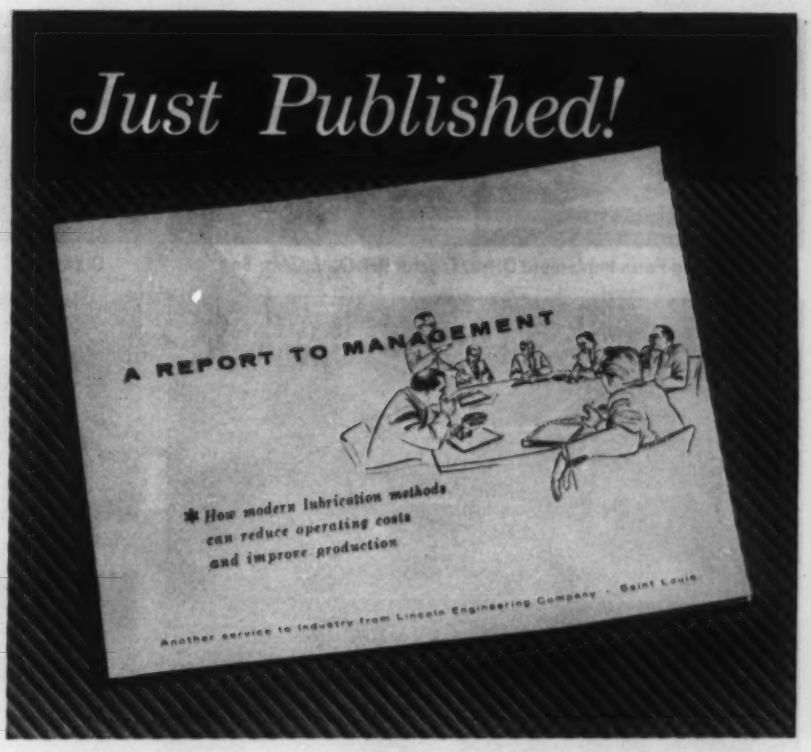
Low-cost, easy-to-install. Systems designed to provide automatic or semi-automatic lubrication of bearings, simultaneously, on single machine units while in operation. May be actuated mechanically, electrically, or manually. Dispense oil or grease.



MICRO-MEASURE SYSTEM

Miniaturized system pre-measures and injects fluid lubricants to millionths of an ounce, providing a totally new type of automatic lubrication. Can be automatically cycled as often as once every 3¾ minutes. Insures constant application of pure lubricant adjustable to individual bearing requirements. Can save more than its total cost in a few weeks.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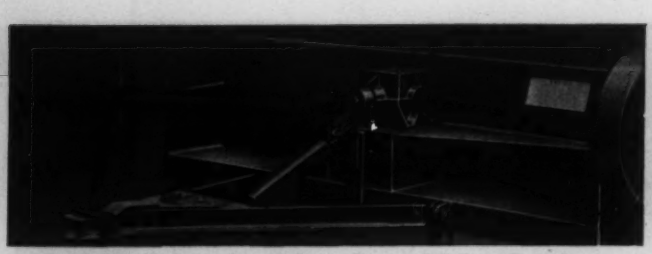
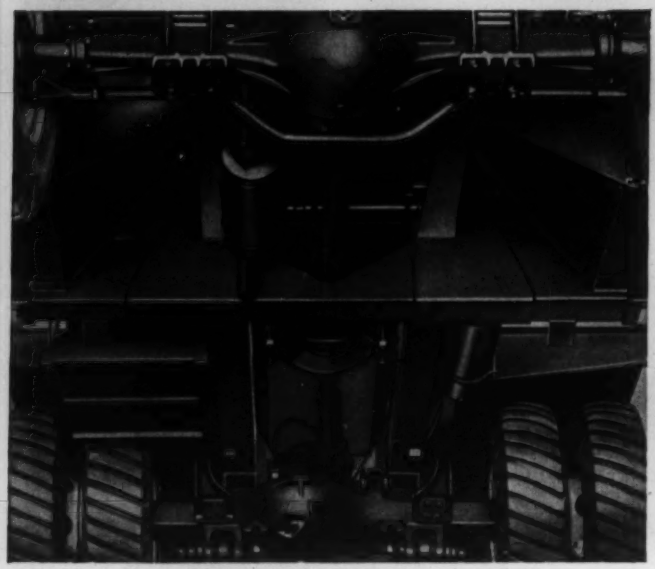


Shielded Farm Implement Drive, Tractor P.T.O. to Gear Box

Differential to Drive Sprocket, Straddle Truck



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Rockwell-Standard engineers see—and help *solve*—a tremendous variety of problems involving a need for universal joints. Applications range from manual steering assemblies...to power take-off drives...to heavy duty propeller shafts.

To "get the power through," Blood Brothers Joints are built in the widest range of types and sizes. This range, plus application experience, can be valuable to you. Whether you want to "take power around corners"...or allow for possible minor misalignments—you can call on Rockwell-Standard engineers.

They'll cooperate to save your staff's time—on common or unusual power transmission problems.

Jointed Screw Conveyor

Tractor Steering Assembly

Transmission P.T.O. Drives Pump and Gear Box

ROCKWELL-STANDARD CORPORATION

Blood Brothers Universal Joints

ALLEGAN, MICHIGAN

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In addition, full research and development facilities are available for new applications, backed by the skills and knowledge of fabrics and coatings that only the combination of Reeves and Vulcan can supply. Whatever your requirements, specify Reevecote and be sure.

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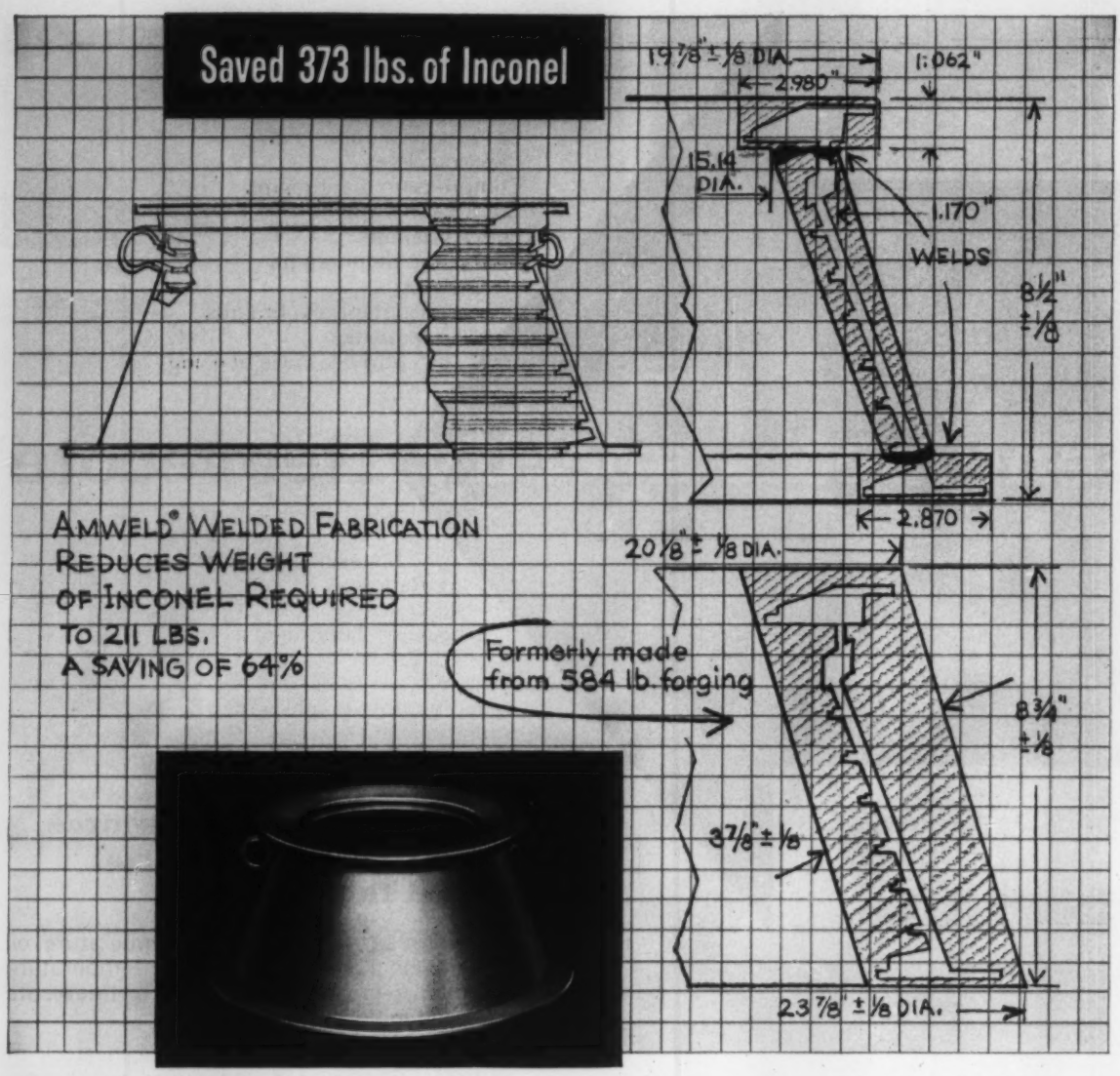

Flash Butt-Welded Ring Assembly Replaces Heavy Forging
SAVES $820.60 on Jet Turbine Casing

This jet engine turbine casing is now produced by Amweld from 3 flash butt-welded rings circumferentially welded together. The result: $820.60 in expensive metal saved on each assembly . . . plus additional savings in machining.

Perhaps Amweld's 40 years' welding experience and special skills in working with hard-to-weld metals can help you solve a fabricating problem.

Send for new catalog of Amweld Welded Precision Assemblies and our instructive booklet, "How Amweld Flash Butt-Welded Rings are Produced." Better yet, mail us your prints and specifications. We will study your problem and work with you.

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THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

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For *extra quiet* operation...

WAGNER 10 HP RESILIENT MOUNTED MOTORS

are vibration free··sleeve or ball bearing

Today, many motors are installed in areas where noise must be held to a minimum — in hospitals, churches, schools, office buildings, restaurants and similar locations where quiet is essential or desirable.

Such installations have created a need for larger polyphase motors that are exceptionally quiet and vibration-free. Wagner has filled this need by expanding its line of polyphase resilient mounted motors to include standard ratings through 10 hp.

If you have an application that calls for a smooth running motor, cushioned by resilient mountings, it will pay you to specify these Wagner Motors—a complete range of ratings from 1 through 10 hp.

Constant research and development have kept Wagner up front in electric motor design for more than 65 years—made the name Wagner one you can trust in choosing electric motor drives.

Your nearby Wagner Sales Engineer can help you select the *right* motor to meet your requirements. There are Wagner branch offices in 32 principal cities.

Wagner Electric Corporation
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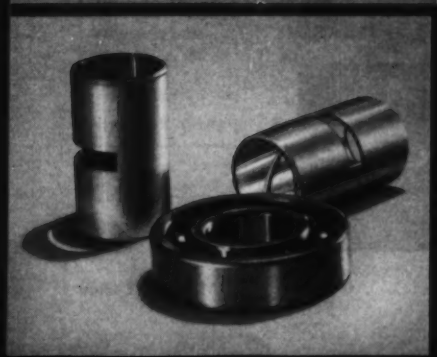
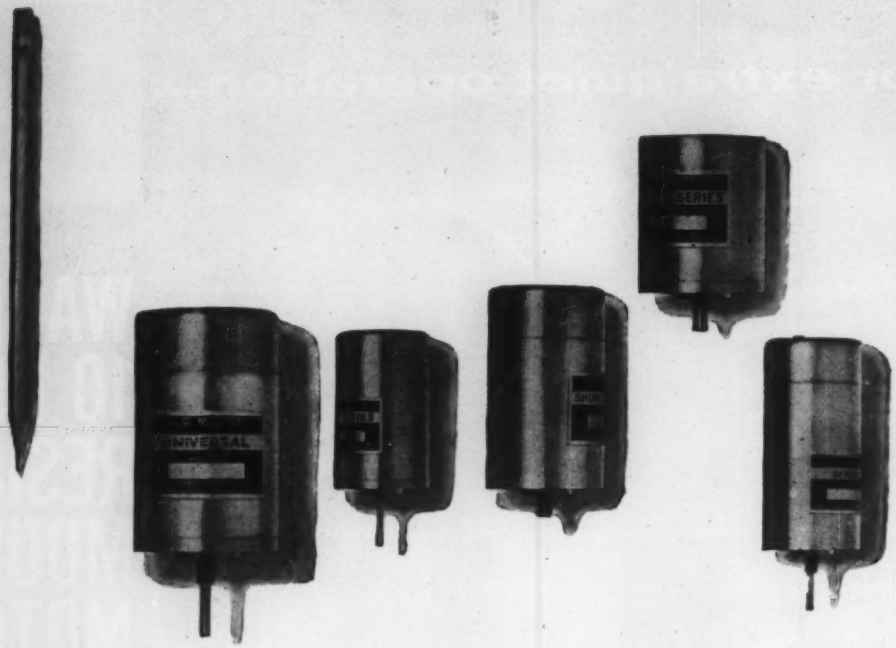
WM59-13

SLEEVE OR BALL BEARING. These motors are furnished with quiet running steel-backed babbitt lined sleeve bearings that have high load carrying capacity. Ball bearings can be supplied when desired.

NEOPRENE CUSHIONING RING. Annular mountings, of neoprene bonded to steel rings, cushion the motor in its cradle base to absorb the small amount of vibration that remains in the most carefully balanced motor.

CEILING, SIDEWALL OR HORIZONTAL MOUNTING. You can mount these motors on walls or ceilings by rotating the cradle base 90° or 180°. The motor is designed to remain completely dripproof in any horizontal position.





NEW WOUND FIELD MOTORS / VERSATILE

Precision miniature wound field d.c. motors in five basic frame sizes (to 2¼" OD and to 1/10 hp) and in countless variations are now available from Globe Industries. You can design them into many military and other high quality products because they meet such an enormous variety of power and duty requirements. **Examples:**

Split-series units reverse rapidly and simply with a SPDT switch. Series units start with relatively high torque, low current drain. Shunt wound varieties offer means for low current control. Universal motors operate on a.c. or d.c. Globe-designed gear reducers, brakes and clutches can be built into the unit, and Globe can efficiently design and build the motor and accessories into a special motorized device.

If you'd like to look into miniature wound field motors of **any** description, or combine them with other components, ask the largest manufacturer of precision miniature motors first. Request technical Bulletin WF-1. GLOBE INDUSTRIES, INC., 1784 Stanley Avenue, Dayton 4, Ohio.

GLOBE INDUSTRIES, INC. GLOBE

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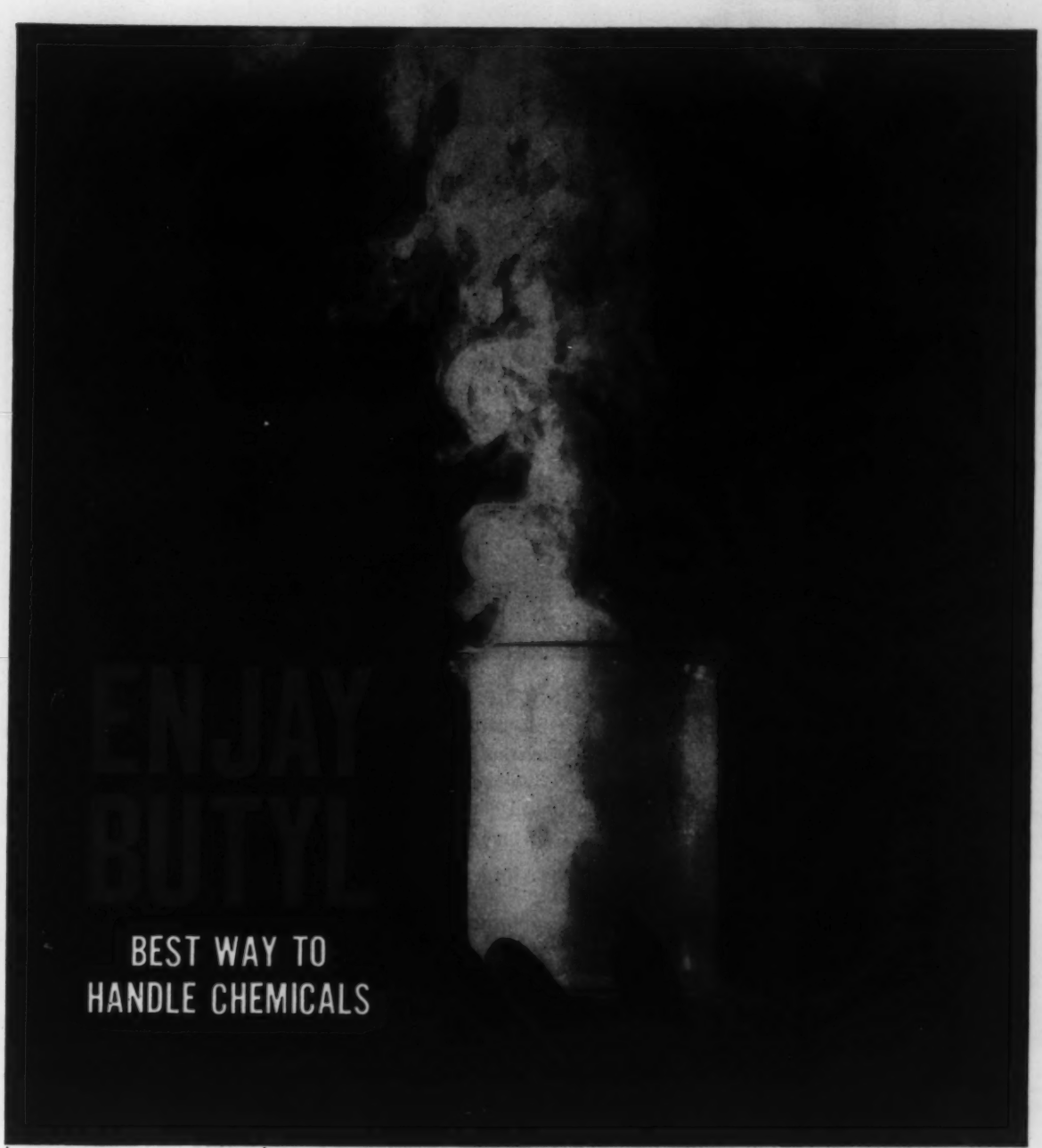

Here are a few of the many chemicals that Butyl offers excellent resistance to:	
Dimethyl hydrazine	Cl Br methane
Phosphoric acid	Ozone
Sulfuric Acid	Hydrofluoric acid
Red fuming nitric acid	Ammonia
Oxygenated solvents	Molten sulfur

Enjay Butyl rubber, due to its unique and extremely low degree of unsaturation, offers excellent resistance to corrosive chemicals. Versatile Butyl is the preferred rubber for countless types of hoses, tank linings, gaskets, seals—and many other applications where exacting chemical resistance is required.

Butyl *also* offers . . . outstanding resistance to weathering, sunlight, heat, and electricity . . . abrasion tear and flexing . . . superior damping properties . . . and unmatched impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

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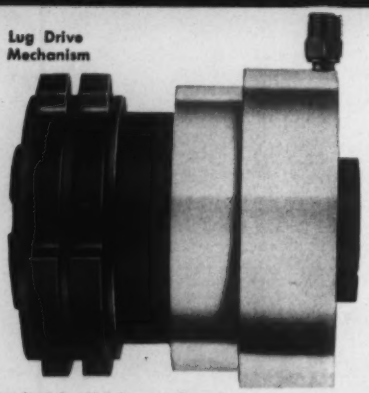
The Clutch with the Original Stationary Air Housing

Stationaire BY CONWAY

- **Middle-Shaft Mounting Accommodation**
- **No Shaft Drilling**
- **Traditional Conway Quality**

Gear Drive with Outflange Adapter

POWER *by Conway* THROUGH AIR



Lug Drive Mechanism

Pat Applied for U.S.A. and Canada

"Just what we have been waiting for" is all we've been hearing. And as usual, Conway has come up with the right answer. Larger units designed specifically for your job. ALL with Conway's traditional conception of high quality at prices within reason.

The World's Most Respected Name in Industrial Clutches for over a Half-Century

WRITE FOR CATALOG 858

MODEL	DRIVE TYPE	NOMINAL WORKING TORQUE AT 60 PSI IN LBS.	DESIGN TORQUE AT 60 PSI IN LBS.
858-3	Lug	210	315
858-5	Lug	1260	1890
858-8	Gear	3780	6300
858-12	Gear	11340	18900
858-14	Gear	15120	22680

★ 6 drives available: Inflange or Outflange Adapter, Bronze bushed or ball-bearing sleeve, Bronze or ball-bearing pilot coupling. Additional models to be introduced soon.

Note: Torque can be increased on all models either by incorporation of sintered bronze drive discs or by increase of air pressure. Please consult the Conway engineers if this is desired.

The CONWAY CLUTCH COMPANY

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Circle 470 on Page 19→

Nickel-Coated THOMAS STRIP Cuts Aladdin's Metal Costs 56%

Aladdin had his fabled magic lamp.

But in real life, Aladdin Manufacturing Company uses nickel-coated Thomas Strip steel to work production magic in its Minneapolis, Minn., plant.

From copper to aluminum to slit steel sheets to plain strip and finally—to cold-rolled strip steel pre-coated with nickel by Thomas Strip Division of Pittsburgh Steel Company.

That's the route followed by Aladdin's Merrill B. (Ted) Wilcox in his five-year effort to find just the right metal for use in his company's line of handsome, useful Jon-E Hand Warmers.

Thomas Strip Division has grown into Aladdin's major supplier of nickel-coated strip because:

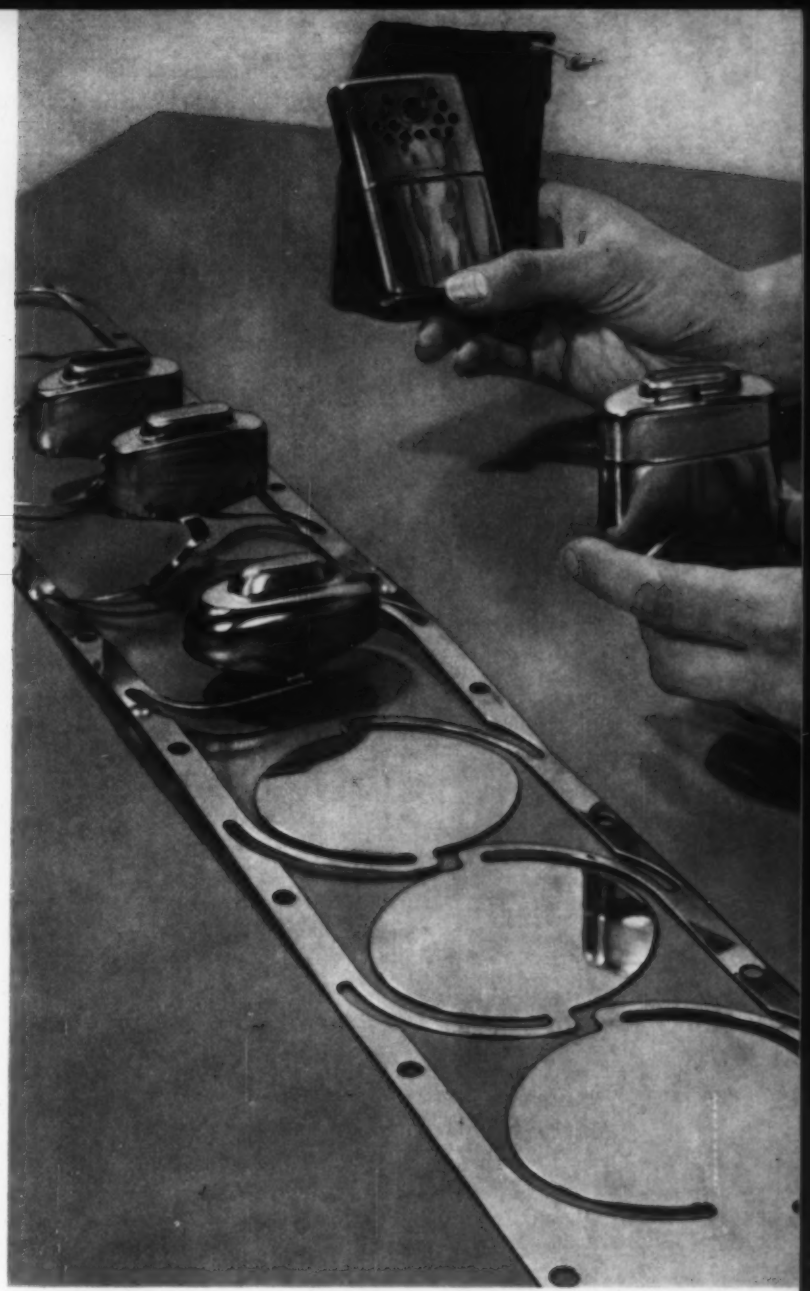
1. **Pre-coated nickel strip cut Aladdin's cost per pound of metal used from 50 cents for plain strip steel to 22 cents.**

2. **Use of nickel-coated strip enabled Aladdin to consolidate four separate production steps—each costing a cent—into a single step.**

3. **Pre-coated nickel cut scrap losses from a high of 20% (with slit sheets) to less than 1%.**

4. **Electrolytic coatings of nickel are more uniform, assuring the necessary snug fit of all Jon-E's components. And the only finishing Aladdin needs on nickel-coated strip is a quick ball-burnishing.**

All the production and design advantages of Thomas Strip are available to you. It is sold plain or electrolytically coated with copper, brass, nickel, chrome or zinc. Thomas also sells a full line of lacquered products. Call the nearest district sales office listed here. Do it today.



SIX-STAGE PROGRESSIVE die forms one Jon-E fuel chamber with every stroke of the press at Aladdin Manufacturing Company. This imposes severe demands on drawability of the 4½-inch nickel-coated steel strip supplied by Thomas Strip Division, Pittsburgh Steel Company. Aladdin credits Thomas Strip with 56% savings in metal costs, as well as sharply reduced scrap loss.

Thomas Strip® Division

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

DISTRICT SALES OFFICES

Atlanta	Cleveland	Detroit	Los Angeles	Pittsburgh
Chicago	Dayton	Houston	New York	Tulsa
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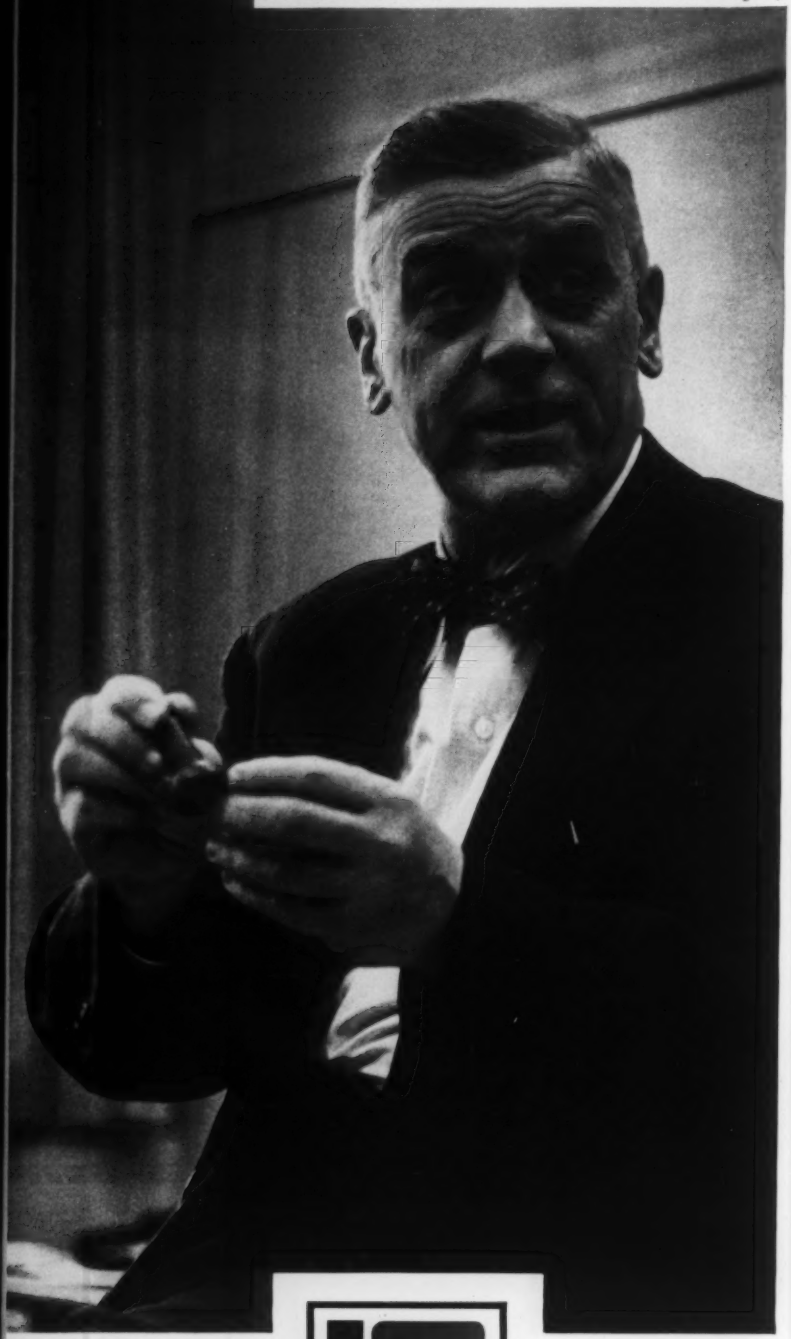
E. H. WERNER, *Production Control Manager, Lamson & Sessions, tells why...*



It's costly to be close-mouthed in ordering fasteners

THE more "specifics" you give us about your fastener needs, the more headaches and money we can save you. For example:

What quantity is required . . . and when? To give you economical production runs, using the most efficient tooling methods, we need specific information. Give us *realistic* quantities — how many must be shipped by a given time—what you expect future usage to be—delivery intervals required. This gives you maximum economy.

What are the physical requirements? Give us the "physicals" and let us recommend the suitable material. When prints specify a steel not commonly used, it must often be procured at a premium, which adds to your cost.

What are the critical dimensions? Close tolerances invariably add to cost. If you indicate which non-critical dimensions might be modified—radii, angles, fillets, lengths, outside and inside diameters, concentricity, etc.—we can often eliminate expensive secondary operations.

What quality level is required? This determines whether 100% inspection is necessary, sample inspection is adequate, or only certain dimensions must be inspected.

Take advantage of the specialized experience and facilities available to you through L & S, to save money and headaches on fastener buying.

L & S Fastener Engineering helps you "tighten up" on...

- **PURCHASING COSTS**
- **INSPECTION AND HANDLING COSTS**
- **ASSEMBLY COSTS**

LAMSON & SESSIONS

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Plants in Cleveland and Kent, Ohio • Chicago and Birmingham

Circle 471 on Page 19

DESIGN

May 28, 1959

Is This Pushbutton Necessary?

JOE, the school-bus driver, was delighted when the Board replaced his beat-up crate with a shiny new model. But his first day at the wheel left him with a terrific backache. Why?

On the new bus, the handle for opening and closing the door moved from side to side in front of the driver. On the old one it had moved toward and away from him. The young designer who made the change thought he had "cleaned up" the operator's station. But he had violated a basic principle of human factors engineering.

Complaints from the field were numerous. Something had to be done. Couldn't return to the old design, of course. Must be modern. How about power operation with pushbutton control?

It worked fine. But along with other similar improvements by the "sophisticated" designer it boosted the price of the bus. The company lost orders in a highly competitive market.

Some engineers pride themselves on the "sophistication" of their designs. They forget that sophisticated means over-refined, artificial, deprived of naturalness or simplicity.

Machines were invented to take the load off men's backs. But power-assist devices are being used, sometimes unnecessarily, to offset or conceal defective mechanism design. And sometimes a little attention to the capabilities, as well as the limitations, of human muscles could eliminate costly controls. Joe Seminara's article in this issue should serve as a gentle reminder as well a source of useful data.

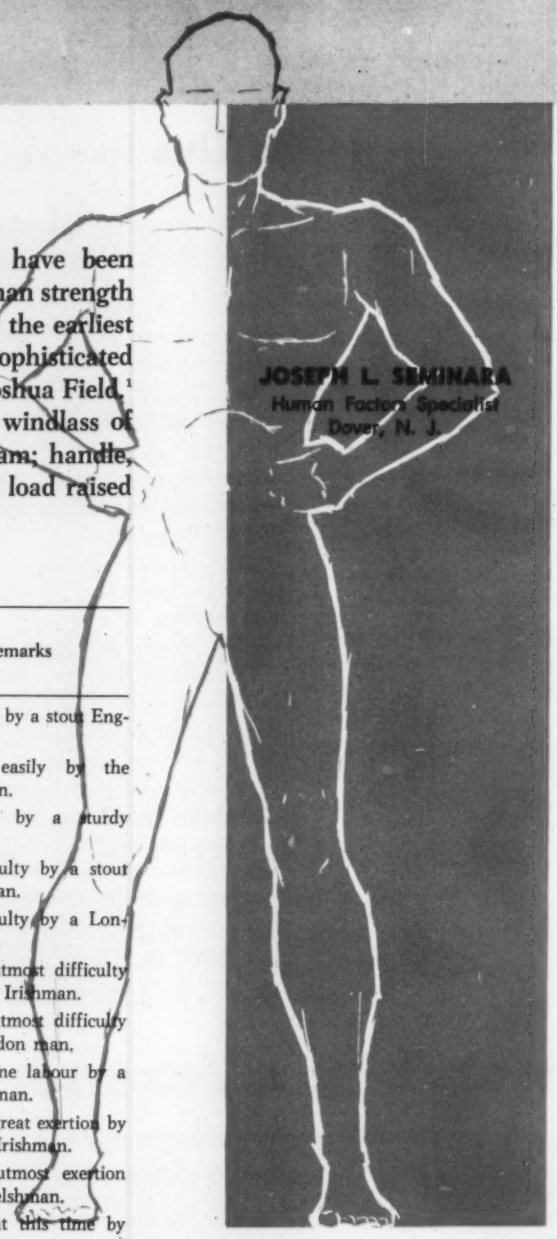
As NMTBA President Ralph Kraut has observed, U. S. manufacturers are pricing themselves out of the world market. Over-sophistication could be a factor in our losses to foreign competition, both at home and abroad. Along with the usual inspirational slogans, design engineers might profitably pin up another one: "Is this pushbutton necessary?"

Colin Carmichael

EDITOR

Muscular ability of equipment operators and handlers is a practical design feature often overlooked. Here are factors to consider and actual values to use when . . .

JOSEPH L. SEMINARA
Human Factors Specialist
Dover, N. J.



An Irishman Gives Up?

Behavioral scientists and physiologists have been concerned with gathering information on human strength and endurance for at least 150 years. One of the earliest studies, which appears quaint from our more sophisticated historical perch, was performed in 1826 by Joshua Field.[1] Field studied the performance of men on a windlass of the following dimensions: Barrel, 11¾ in. diam; handle, 18 in. long; ratio of power to weight, 1:105; load raised 16½ ft. The following results were obtained:

[1]References are tabulated at end of article.

Statical Resistance of Load at Handle (lb)	Load Raised (lb)	Time in Raising (min)	Equivalent Power (ft-lb/min)	Remarks
10	1050	1.5	11,550	Easily done by a stout Englishman.
15	1575	2.25	11,505	Tolerably easily by the same man.
20	2100	2.0	17,325	Not easily by a sturdy Irishman.
25	2625	2.5	17,329	With difficulty by a stout Englishman.
30	3150	2.5	20,790	With difficulty by a London man.
35	3675	2.2	27,562	With the utmost difficulty by a tall Irishman.
35	3675	2.5	24,225	With the utmost difficulty by a London man.
35	3675	2.83	21,427	With extreme labour by a tall Irishman.
35	3675	3.0	20,212	With very great exertion by a sturdy Irishman.
35	3675	4.05	15,132	With the utmost exertion by a Welshman.
35	3675	—	—	Given up at this time by an Irishman.

Designing for

HUMAN STRENGTH

HUMAN-FACTORS specialists are continually being asked for information concerning an operator's physical capacities. Typical questions are:

1. Will a man be able to install components weighing 80 pounds?
2. This piece of test equipment weighs X pounds. Will one man be able to carry it?
3. How much force can the average man be expected to exert on a pedal control?

If demands on human strength are unrealistically high, inefficient and perhaps unsafe operator performance can be anticipated. On the other hand, if human strength is underestimated, unnecessary expense and design effort will be incurred in reducing component weights or in designing for an operation requiring two men where one would be sufficient.

In addition to the different strength capabilities of various body members, other factors that must be considered are:

1. Age of the operator.
2. The plane in which forces must be exerted with relation to the rest of the body.
3. Direction of the force, i.e., push or pull.
4. Shape of the weight or control to be manipulated.
5. Length of time of exertion.
6. Preferred side of body of the operator.

To generalize from the data presented here, the conditions under which the data were acquired must be considered. For example, it would be unrealistic to use back-strength data for young pilot trainees in prime physical condition to design equipment for factory workers who can be expected to range in age from 18 to 65 years.

When deciding what strength value to use in designing equipment, the designer must consider the percentage of population he can expect to accommodate. Very often the design engineer asks for the "average" strength capabilities of men. However, if an average strength value is chosen, half the people concerned would be able to meet the strength requirements and the other half wouldn't. Ordinarily this situation is not acceptable because it would involve a rigid selection program. The value usually accepted for design use is determined from the 95 per cent level of accommodation.

General Facts Concerning Human Strength

Age: The strength of males increases steadily until approximately 30 years of age. This increase is most rapid between the ages of 12 and 19. Similarly, women reach their peak strength at 30 years. However, the strength of women increases more uniformly between the ages of 9 and 19 years.

Sex: Women are approximately 30 per cent weaker than men.

Handedness: The left hand and arm are generally 10 per cent weaker than the right hand and arm.

Exercise: Although it has long been accepted that exercise will increase strength, few quantitative studies have been undertaken. One study showed

that strength is most rapidly augmented when the individual exercises with a load requiring use of approximately two-thirds of his maximum strength. In addition, one daily training session during which the load is held for six seconds is as good as more frequent or longer sessions.

Strangely enough, exercising one side of the body also improves performance of the other side. In one study, twenty male subjects were divided into two groups of ten. The experimental group received three weeks of exercise of the right arm. The other group received no exercise with either arm. The experimental group did considerably better with the left arm after the exercise period than did the control group.

Endurance: Strength means a momentary, single-task, maximum exertion, or a sustained effort. Endurance refers to a sustained effort. Findings show that endurance is enhanced by exercise, rest, food, and increased atmospheric pressure. On the other hand, fatigue, hunger, low atmospheric pressure, high temperature accompanied by high humidity, and tobacco reduce endurance. Muscular power is also reduced by excitement and by mental work. And lastly, males have greater endurance than females.

Strength of Hand Grip

Operation of some controls requires a contraction or gripping of the hand. Since hand grip is a relatively easy strength variable to measure, reliable data have been obtained.

Young Men

Type of Value	Right Hand (lb)	Left Hand (lb)
Range	100 to 170	90 to 163
Average	135	125
Design Value	105	100

Reference 2.

General Male Industrial Workers

Type of Value	Preferred Hand (lb)
Range	75 to 170
Average	125
Design Value	99

Reference 3.

Leg Strength

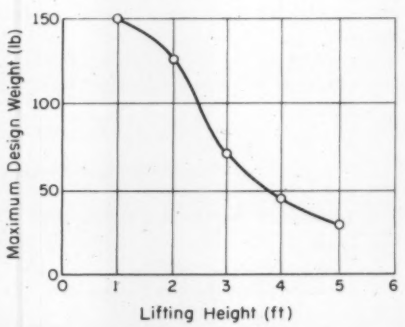
Use of pedal controls is often encouraged when the operator's hands are overburdened. Studies of leg strength have been conducted using 515 aviation students and officers as subjects. Leg strength measurements were made while the subject was seated and wearing a safety belt. Results indicate that it is a good idea to use pedal controls where large control forces must be exerted.

Type of Value	Right Leg (lb)	Left Leg (lb)
Average	564	602
Design Value	331	369

Reference 5.

Lifting Height

Maximum weight values for objects of convenient size and shape are shown. With ample work space, 95 per cent of young men can lift these weights to the heights indicated.[6]



Rest Periods: Recovery rate after a standard exercise has been found to be 40 per cent after a 1 minute rest, 65 per cent after 2 minutes rest, 85 per cent after 4 minutes rest, and 96 per cent after 8 minutes rest.

Effect of Alcohol: Small amounts of alcohol, from 1/3 to 2/3 oz, generally increase muscular output or retard fatigue when the operator is initially not tired. However, while output may be increased, muscular co-ordination suffers; for example, eye-hand co-ordination is impaired. When 2 to 2-2/3 oz are taken, there is either no improvement or a deterioration in performance.

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5. E. R. Eibel—"Relationship of Leg Strength, Leg Endurance, and other Body Measurements," Project Report No. 318, AAF School of Aviation Medicine, Randolph Field, Texas, August, 1945.
6. J. W. Altman and J. D. Folley—"Guide to Design of Electronic Equipment for Maintainability," Wright Air Development Center Report 56-218, April, 1956.
7. *Handbook of Human Engineering Data*, Second Edition, Tufts College, Medford, Mass., 1952.

Arm Strength

Subjects used in this analysis were young men 17 to 25 years old. Arm strength measures were made with arms straight out. (Reference 4)

Push

Type of Value	Right Arm (lb)	Left Arm (lb)
Range	33 to 215	26 to 215
Average	138	126
Design Value	50	42

In

Type of Value	Right Arm (lb)	Left Arm (lb)
Range	16 to 131	10 to 119
Average	50	43
Design Value	20	13

Pull

Type of Value	Right Arm (lb)	Left Arm (lb)
Range	26 to 185	31 to 182
Average	120	116
Design Value	52	50

Out

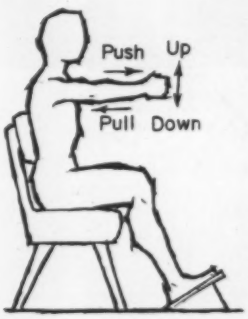
Type of Value	Right Arm (lb)	Left Arm (lb)
Range	10 to 158	5 to 110
Average	35	30
Design Value	14	8

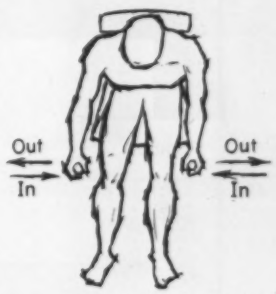
Up

Type of Value	Right Arm (lb)	Left Arm (lb)
Range	9 to 101	4 to 105
Average	43	41
Design Value	14	9

Down

Type of Value	Right Arm (lb)	Left Arm (lb)
Range	13 to 116	10 to 89
Average	41	35
Design Value	17	13



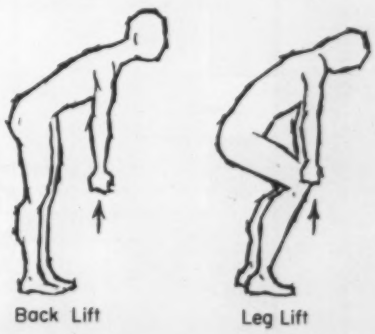


Back and Leg Lifts

Weight values are given for a maximum momentary physical exertion and should not be used to specify weights which are to be manipulated in any manner. These values can be used for control forces requiring large actuating force for a very brief time. The subjects used in acquiring this information were young Air Force students in prime physical condition.

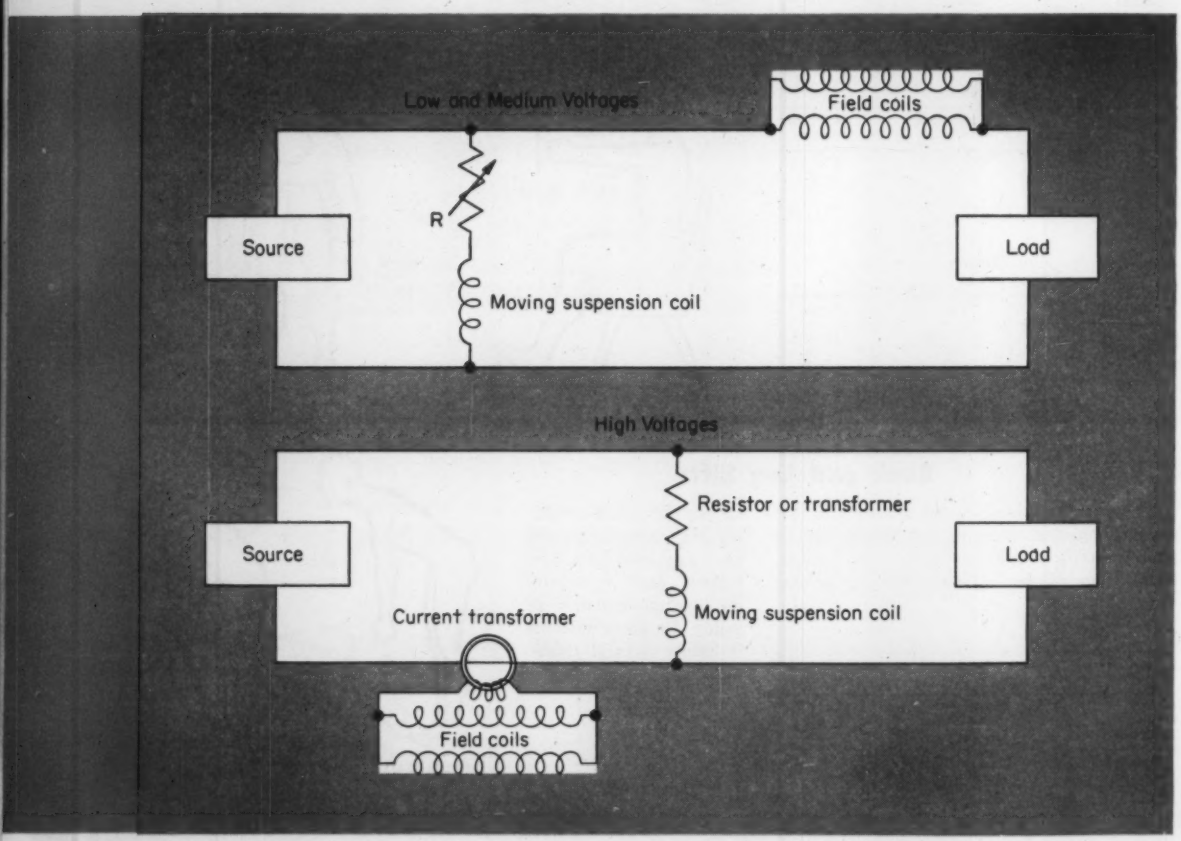
Type of Value	Back (lb)	Leg (lb)
Range	330 to 800	700 to 2500
Median	520	1482
Design Value	375	940

Reference 7.

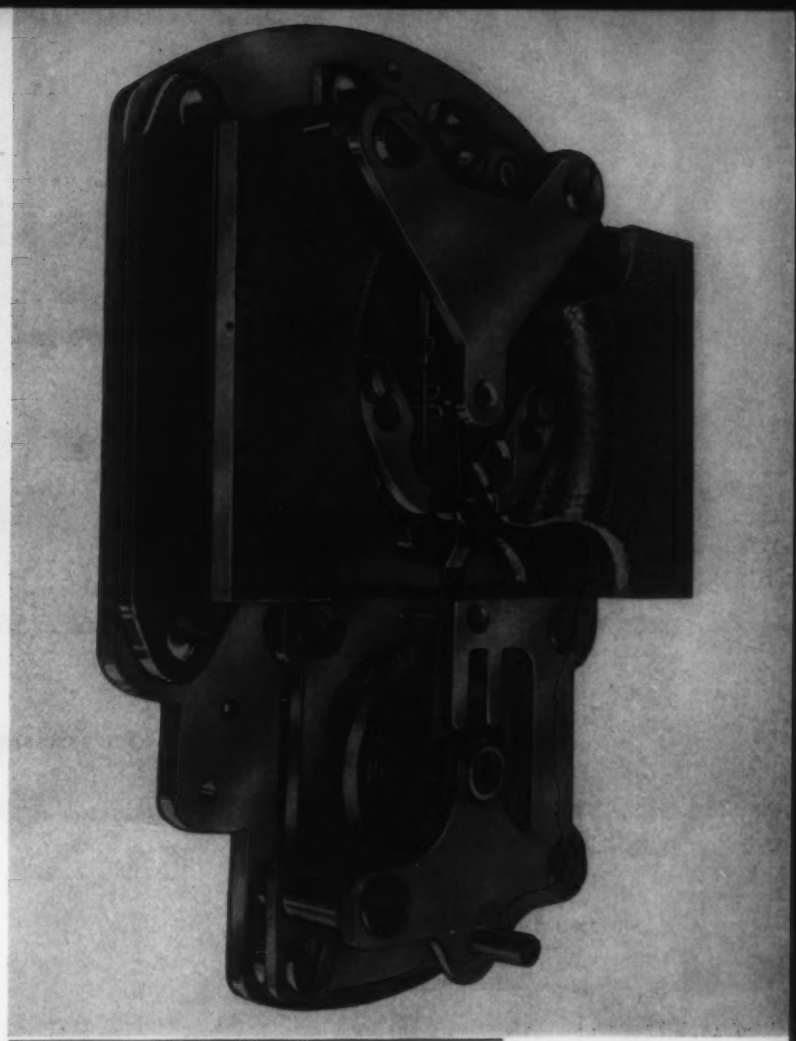


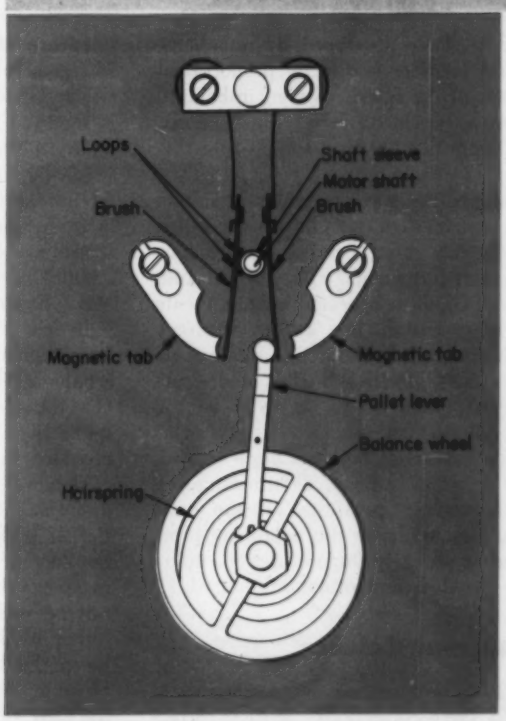
scanning the field for *ideas*

Twin field coils permit galvanometer to add, subtract, and multiply variables in computing operations. As employed in an instantaneous-watt galvanometer developed by Consolidated Electrodynamics Corp., two identical, isolated field coils are mounted on opposite sides of a suspension coil. The field coils are separately excited. Torque developed by the field-coil currents and the suspension-coil current rotate the suspension coil. Angle through which the suspension coil rotates is proportional to the algebraic sum of the field-coil currents multiplied by the suspension-coil current. Holding one or two of the currents constant and permitting the remaining currents to vary causes the deflection to vary as a sum or product. For subtraction, polarity of one of the field coils is reversed.



"Five beat" pulse control clock movement starts and stops battery-driven dc motor which drives the indicating hands. In a clock developed by Sessions Clock Co., the speed of the clock motor is governed electrically. In the motor, which has a field of two permanent magnets, three coils on the rotor are connected in series. Junction points are connected to three segments of an eccentric commutator. Two of the commutator segments are loops of gold wire and the third is a sleeve on the rotor shaft. A pallet lever and balance wheel assembly restrains the brushes so they can't stay in contact with the commutator as the motor rotates. When the balance wheel swings through center, it releases the pallet lever, allowing the brush to make contact with the commutator sleeve and complete the motor circuit. As the motor rotates, the motor circuit is almost immediately broken when the gold loop commutator segments leave the opposite brush spring which is being restrained by the pallet lever. The circuit remains opened until the balance wheel again swings back through center, allowing the opposite brush to make contact with the sleeve on the commutator. In operation the balance wheel oscillates at 5 beats per second, governing motor speed at 150 rpm.





Designing For Balance

in rotating parts and assemblies

Part Design • Assembly Practices •

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CENTRIFUGAL force developed by unbalance in a rotating member is directly proportional to the square of the speed. For an unbalance of 1 oz acting at a radius of 1 in., Fig. 1, force produced at 1000 rpm is 1.78 lb. At 8000 rpm this force increases to 114 lb.

Forces of unbalance can have several undesirable effects. In a dynamic system, they represent added inertia load which may affect bearing performance and system power requirements. They also cause motions which contribute to operator fatigue, create a "rough feel" in operation, and reduce accuracy of machine performance. In addition, motion excited in hydraulic lines, electrical wiring, and structural elements can contribute to, or even be the cause of fatigue failure.

As the need for balancing becomes more critical, design can play a major role in determining the effectiveness of balancing operations. If the basic requirements and limitations of the balancing process are considered at an early stage of design, many problems can be avoided, and others minimized.

Inherent Balance

When a part is to be balanced, large amounts of unbalance require large corrections. If such corrections are made by removal of material, additional cost is involved and part strength may be affected. If corrections are made by addition of material, cost is again a factor and space requirements for the added material may be a problem.

Ideally, rotating parts should always be designed for inherent balance, whether a balancing operation is to be performed or not. Where low operating speeds are involved and the effects of a reasonable amount of unbalance can be tolerated, this practice may eliminate the need for balancing.

In parts which require unbalanced masses for functional reasons, these masses can often be counterbalanced by designing for symmetry about the axis of rotation. Thus, where a boss is required on one spoke of a pulley, another unused boss might be provided at the same radius on the opposite spoke.

However, such symmetry is not always possible or desirable. Consider the design shown in Fig. 2*a*. Center of gravity of the wedge-shaped section does not lie on the axis of rotation. Here a corrective mass can be added to the "light" side or a void can be included on the "heavy" side to move the center of gravity to the axis. Corrective mass may be in the form of a single weight, Fig. 2*b*, or may be split, Fig. 2*c*, to accommodate a boss or hole in the part.

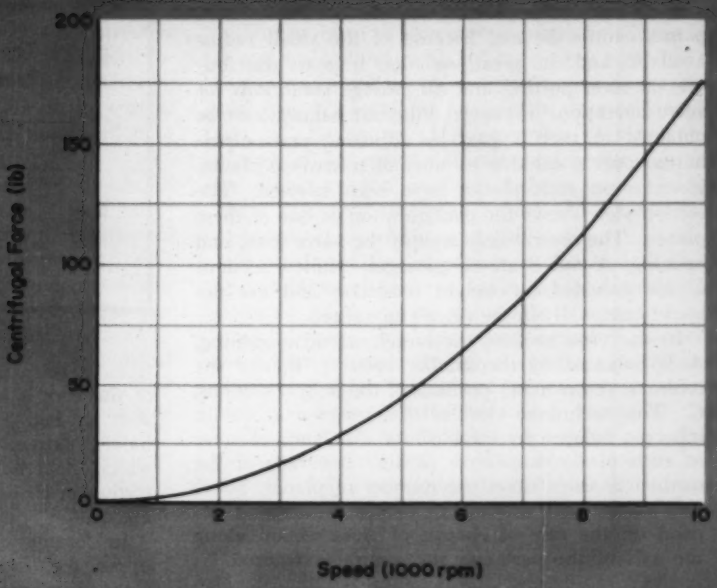

Fig. 1—Centrifugal force developed by 1 oz-in. of unbalance in rotating part.

Unbalance Correction • Balancing Tolerances

Another method of obtaining inherent balance utilizes corrective masses in each of two planes. This approach, which represents the general solution for conditions of unbalance, is employed where correction cannot be made directly in the plane or planes of unbalance, Fig. 3. Two convenient planes of correction are selected and the corrective masses are determined by resolution of moments and forces to satisfy equilibrium conditions.

A useful variation of this approach employs a series of weights at points along the axis of a part, but not in the same transverse plane as the individual unbalances which they counterbalance. Such an arrangement is used to balance crankshafts at each throw by placing corrective weights in adjacent cheeks in a series of relationships of the type depicted in Fig. 3.

In some parts, distribution of mass along the axis of the part can make design calculations difficult. Often, two planes may not be available for substantial corrective masses because of space and functional requirements for the assembly and the part. For example, the distributor valve in Fig. 4 is located on the centerline of rotation and is entirely enclosed within other parts in assembly. No space is available for external addition of masses.

Internally, the net requirement for balance in two

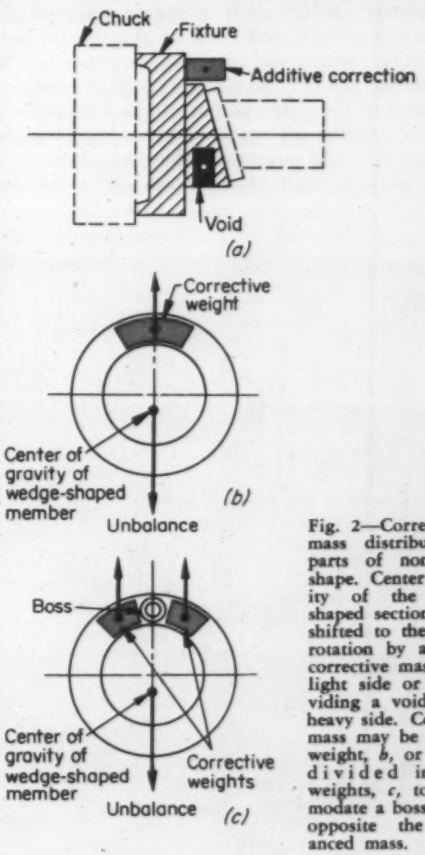

Fig. 2—Correction of mass distribution in parts of nonuniform shape. Center of gravity of the wedge-shaped section can be shifted to the axis of rotation by adding a corrective mass to the light side or by providing a void on the heavy side. Corrective mass may be a single weight, *b*, or may be divided into two weights, *c*, to accommodate a boss or hole opposite the unbalanced mass.

planes cannot be met because of the small radius available and the great variation in mass distribution to meet porting and oil-passage conditions for valve operation. However, inherent balance can be obtained in such a part by adjusting mass distribution over a suitable number of transverse planes. Here, seven such planes have been selected. The section view shows the configuration at one of these planes. The central hole accepts the valve stem, and openings *A* and *B* are oil passages. Hollow sections *C* are provided for weight reduction and are not used functionally in the valve's operation.

In this cross section, the larger eccentric opening, *A*, is balanced by the smaller opening, *B*, and the eccentric (correction) portions of the hollow sections, *C*. This technique enables the designer to obtain inherent balance by establishing a balance of areas in each of the transverse planes. Accuracy of the method depends upon the number of planes. Selection of the best number of planes to use will depend on the rate of change of cross section along the axis of the part and the accuracy required.

Dimensional Control

After inherent balance has been designed into a part, lack of proper dimensional control in manufacture can still result in excessive amounts of unbalance and increased costs in the measuring and correcting operations. In the extreme condition, this unbalance may exceed the range of possible correction and the part will have to be scrapped. Since this occurs after all machining has been completed, it represents the largest possible scrap loss.

In castings, shift of the cores can result in extremely large unbalances. Effect of a lateral shift of the core is shown in Fig. 5*a*, and of an angular shift in Fig. 5*b*. Also, shifts in position of mold halves, pattern inaccuracies, and casting techniques which yield hollows, blow holes, and excessive distortion in cooling all contribute to large unbalances, Fig. 5*c*.

In forging operations, excessive washing of the upper die, especially, leaves substantial eccentric mass distribution in that direction. In addition, accumulation of scale in the lower die will cause further shift of mass in the upward direction.

Net effect of these two forging conditions is depicted in Fig. 6. This four-throw, opposed crankshaft is forged with its centerline in a horizontal position. Unbalance corrections, requiring removal of large amounts of material in the balancing operation, can be costly. In addition, this part has a restricted sector (angular) in which correction can be made. Large eccentric masses can throw the target unbalance outside of these sectors so that the finished crankshaft cannot be balanced and must be scrapped.

Table 1—Centrifugal Force Produced by Eccentricity of Rotating Cylinder*

Speed (rpm)	Centrifugal Force (lb) e=0.0001 in.	e=0.001 in.	e=0.005 in.
1,000	0.6	6	30
5,000	15	150	450
10,000	64	635	3175

*Data based on 10 in. dia by 10 in. long steel cylinder; e=eccentricity.

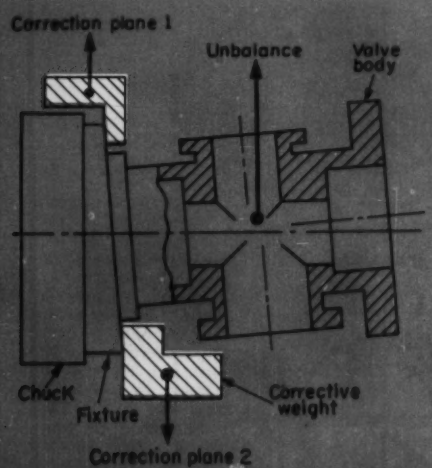

Fig. 5—Two-plane method of unbalance correction. Planes of correction are separated as much as possible to cut down the size of the corrective weights required.

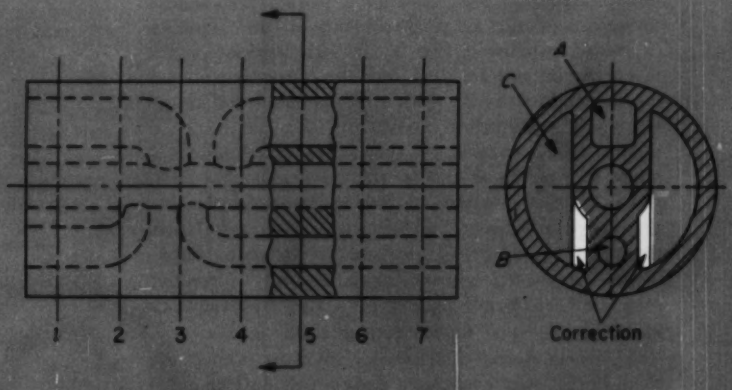

Fig. 4—Multiple-plane method of unbalance correction. A series of seven transverse planes of correction are provided along the axis of this aircraft-propeller distributor valve. Inherent balance of the part is obtained in design by balancing the areas in each of the planes of correction. Section view shows details of area modification for cross section at plane 5.

In parts of the types just discussed, unfinished surfaces can cause large unbalances. A corrective measure is to machine these surfaces. Decision depends upon the relative cost of corrective machining for balancing purposes only, as well as the cost of adequate quality control and design modification to overcome the problem.

Where all surfaces are to be machined, certain design practices can help to keep costs to a minimum. Surfaces which locate the axis of rotation of the part should be examined for concentricity with the principal masses of the part. Fig. 7*a* demonstrates the effect of lack of concentricity in a large disc where the center of gravity is displaced upward.

Effect of such eccentricity on a typical cylindrical element is summarized in Table 1. Effect of a similar eccentricity condition, but with the two journals offset in opposite directions, is shown in Fig. 7*b*. Here, if the right and left halves of the large disc are considered individually, the respective centers of gravity are displaced upward and downward, producing an unbalanced couple.

The problem of excessive eccentricity of journals, bores, and splines, with respect to principal masses, can often be solved by re-examination of the order and type of operations involved in the part's manufacture. Reduction of the number of setups employed, closer control of relationship between major diameters and locating surfaces, and, perhaps, better quality control can reduce the magnitude of unbalances to within acceptable values.

Where operation sequence is changed, little, if any, additional cost is involved in manufacture. Locating journals from the major diameter, or vice versa, in the machining process, instead of producing them from separate chuckings (perhaps on different diameters), is an example of an inexpensive change which will simplify the balancing operation.

Where more accurate quality control or closer tolerances are required, a study of the relative machining and correction costs will usually indicate the amount of additional accuracy warranted.

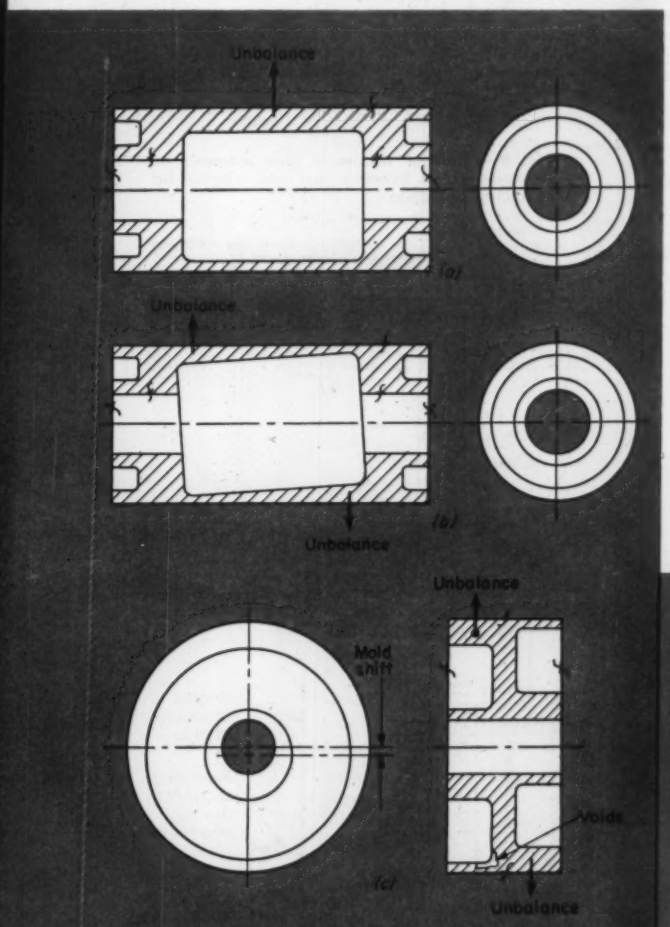

Fig. 5—Effect of casting errors on part unbalance: *a*, lateral shift of core; *b*, angular shift of core; *c*, shift in position of mold halves.

Balancing Fits

In the balancing procedure, the part to be balanced must be located accurately with respect to its axis of rotation in final assembly. Thus, the same fit surfaces which later will locate the part in assembly should be specified for location on the balancing machine.

If a bore in a rotating part is used to locate the part in assembly, the simplest device for locating the part for balancing would consist of an adapter with a plug to fit the bore. Fit obtained for balancing purposes is a function of bore tolerance, allowance for manual assembly of the part on the adapter, and tolerance on plug diameter. For a part with maximum bore diameter, the condition of looseness which results is depicted in Fig. 8.

As the part is rotated, displacement caused by this looseness can produce an apparent unbalance where there is actually "perfect" balance. Standard

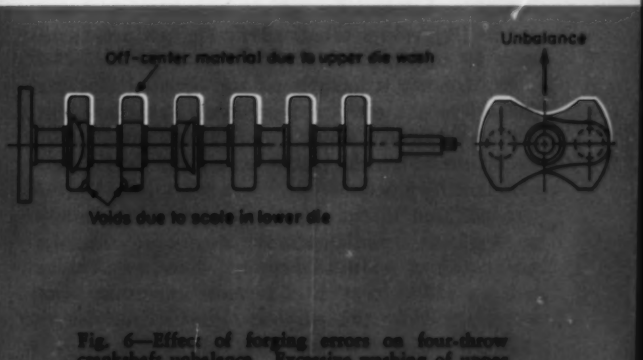

Fig. 6—Effect of forging errors on four-throw crankshaft unbalance. Excessive washing of upper die plus accumulation of scale in lower die can cause substantial eccentric mass distribution in direction of upper die.

measuring equipment has for many years been capable of detecting displacements of a part's center of gravity as small as 0.000025 in. while the latest equipment will detect motions of 0.000002 in. Thus, accuracy of location of a part in the balancing operation is one of the limiting factors in accuracy of balance. Control of size tolerance on bores and splines used for location in balancing should, therefore, be considered not only from the standpoint of assembly fit, but also with respect to the balancing requirements for the part.

Other Error Sources

One of the requirements for accurate reduction of unbalance in the correction operation is that the angle of unbalance be established to within tolerances which insure small errors. For this function of index, references such as keyways, spline teeth, holes of various types, pins, etc., can be used. Whatever the configuration, size, and sometimes radial-location, variation is an important consideration. Fig. 9 illustrates use of an adapter with a key to fit the rotating member's keyway. Looseness (enlarged view) is a result of maximum tolerance on keyway width, minimum width on adapter key, and allowance for manual placement of part on adapter when the minimum keyway is encountered. The key is shown in position for driving the part for unbalance measurement. Because of looseness, the centerline of the key is angularly displaced from the centerline of the keyway.

After the measurements have been taken and the machine is stopped, the part must then be indexed to the proper position for adding or removing material. If, in this second part of the balancing cycle, the key moves over to the opposite side of keyway, a total angular error of twice the original angle between keyway and key centerlines results.

The effect of removing or adding material in the correction procedure is shown in Fig. 10. Magnitude of the resultant error is a function of the amount of angular error involved, and the amount of the original unbalance for which correction is being made. The values tabulated in Fig. 10 are based on a 10 oz-in. unbalance.

If unbalance reductions on the order of 20:1 are required in the correction procedure, angular-index accuracy is critical, especially since this error is only one of several which must be considered in the overall balancing process.

In addition to the effect of tangential variations in size of configurations used for angular index, such as width of keyways, diameter of holes, etc., the radial location of holes is important when they are used for this purpose. Effect of radial variation in hole position is shown in Fig. 11. Fig. 11*a* illustrates the effect of maximum and mininum radius of hole centerline on the size of adapter index pin which will enter the hole. The combination of this variation with the variation in hole diameter results in an angular error which is maximum

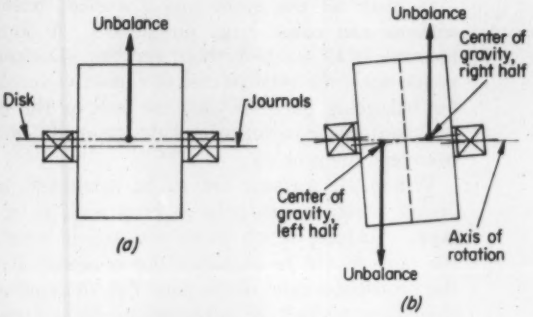

Fig. 7—Effect of concentricity errors on unbalance of cylindrical parts. At *a*, offsets at each journal are equal and in the same direction. At *b*, offsets are in opposite directions, producing an unbalanced couple.

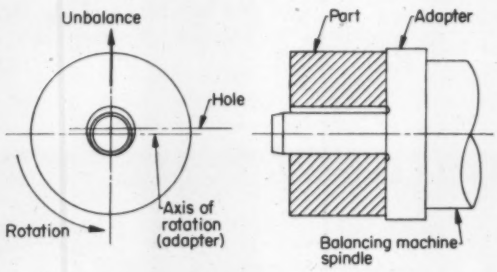

Fig. 8—Effect of maximum bore diameter on looseness of fit between part and adapter for balancing operation.

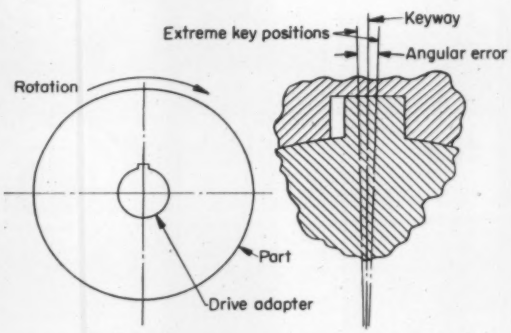

Fig. 9—Effect of fit between keys and keyways on angular error in indexing operations during the balancing procedure.

Angular error (degrees)	Correction error (oz-in.)
1	0.17
2	0.35
3	0.52
4	0.70
5	0.87
6	1.05

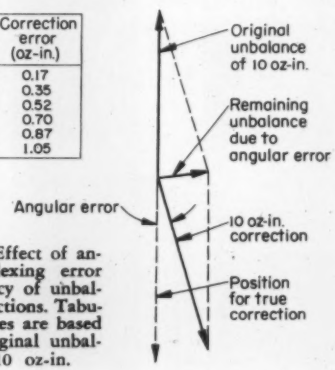
Original unbalance of 10 oz-in.
Remaining unbalance due to angular error
Angular error
10 oz-in. correction
Position for true correction

Fig. 10—Effect of angular indexing error on accuracy of unbalance corrections. Tabulated values are based on an original unbalance of 10 oz-in.

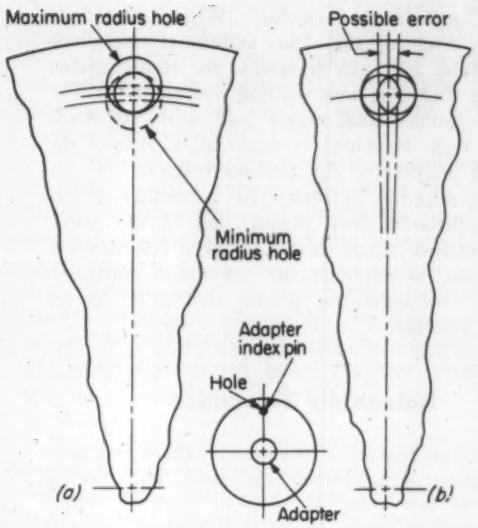

Fig. 11—Relationship of radial variation in hole position to angular error of index. Effect of variation in radius of hole centerline on size of adapter index pin that will enter the hole is shown at *a*. Angular error caused by a combination of radius and hole-size variation is a maximum when hole radius is nominal, *b*.

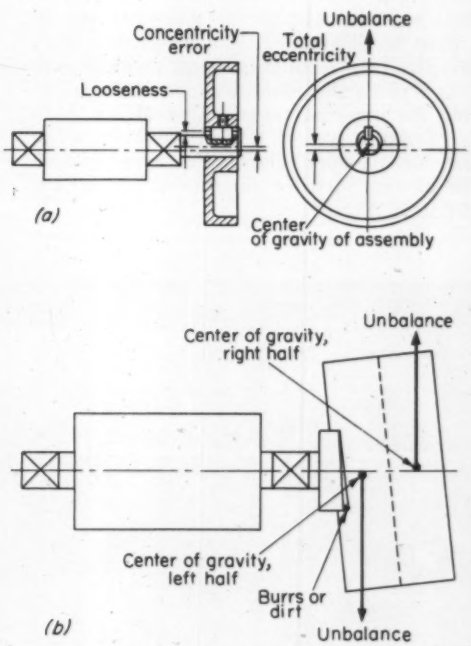

Fig. 12—Assembly errors that can cause unbalance. At *a*, looseness between pulley and shaft causes pulley to be displaced when set screw is tightened. At *b*, squareness errors, burrs, and dirt at the mating surfaces of assembled parts cause angular displacement of the axis of the mounted part, producing an unbalanced couple on the assembly.

when the hole radius is nominal, Fig. 11*b*.

Sometimes the engineering requirement for operational accuracy of a part does not require very close tolerances on such configurations. Then, the balancing requirement must be considered, and restriction of tolerance applied accordingly. This decision should be made early in the design of the part before tooling has been ordered.

For accurate angular location, the radius to the configuration used is a linear influence: The smaller the radius, the greater the angular error. When keyways on small shafts are the only available means for angular location and could lead to large index errors, a special hole, slot, pin, or keyway accurately located at an acceptable radius might be less expensive than the demands which poor index would place on the rest of the balancing operation.

Assembly Fits

When previously balanced parts are assembled, the accuracy of fit, as well as the concentricity of fit surfaces with members which determine the axis of rotation, can account for considerable unbalance.

Fig. 12*a* shows how looseness between pulley and shaft can produce displacement of the pulley when the set screw is tightened. If, in addition, this portion of the shaft on which the pulley fits is eccentric with the journals, the center of gravity of the pulley can be further displaced. Without any contributing unbalance in either shaft or pulley, an unbalance will be produced in assembly equal to the displacement of the pulley's center of gravity times its weight.

In addition to this type of translatory displacement, inclination of the mounted part's axis to the axis of rotation will also cause unbalance. Fig. 12*b* demonstrates how such tilt of the part is a function of mounting-face squareness and the presence of burrs and dirt at the face surfaces.

The principal effect of such tipping of the mounted part is to produce an unbalanced couple. However, some static or force unbalance may also occur, depending upon where the center of gravity of the entire mounted piece falls along the axis. If the displacements of the centers of gravity of the two halves of the mounted part are considered, the source of such an unbalanced couple is readily apparent. This effect is added to the effect of translatory displacement and is similarly sensitive to dimensional variation.

Relationship of the accuracy in fits, squareness, and concentricity of assembled parts to balancing tolerance requirements calls for a decision on the basis of cost. Parts will be balanced originally to some tolerance which is a compromise of design requirements and costs. Like all other types of machine operations, increased accuracy in the balancing process demands greater investment in better quality equipment.

When the economics of machining accuracies,

unbalance measurements, and correction requirements indicate that the total cost required to maintain the desired balancing tolerance is prohibitive, balancing of the assembly itself is then indicated. This assembly-balancing procedure may eliminate the requirement for balance of some of the component parts, or at least permit relaxing of the tolerances on these parts. As the requirements for balance control become increasingly restrictive, this assembly-balance approach is finding more and more favor, and is now the accepted approach in the automotive field, for example.

Planned Correction

Method of unbalance correction should always be considered in the design stage. If correction is to be provided by removal of material from the heavy side of the part, the effect of such removal on strength, and possibly deflection, of the part should be checked. If correction is by addition of material, such as washers, solder, clips, etc., the effect of deflection within the part, and the requirement for clearance to accommodate the largest required correction should be examined.

When possible, the number of individual corrections required to secure balance should be kept to a minimum. Several small drilled holes will involve additional sources of error as compared with a single drilled-hole correction. Errors which result from control of drill depth and drill-point angle will be involved several times instead of only once. Also, because of the additional indexing and drilling operations required, this method represents greater correction cost.

The radius at which correction is to be made should be determined. The greater this radius, the less the material that will have to be removed or added.

If possible, 360 degrees should be made available for unbalance correction. When corrections must be resolved, Fig. 13*a*, additional operations are involved. Fig. 13*b* represents the recommended approach. Indexing and drilling operations in Fig. 13*a* are doubled and nearly half again as much material must be added or removed because of the off-angle position of the two corrections.

In the selection of planes for correction of dynamic unbalance (two planes), all of the previously discussed factors should be taken into account. In addition, to minimize the amount of correction required, the balancing planes should be as far apart as possible.

Balancing Tolerance

Balancing-accuracy requirements affect not only the selection of measuring equipment, but also the method of correction. Consider a part for which a balancing tolerance of 0.05 oz-in. has been established. If the available measuring equipment can establish the condition of unbalance to within 0.01 oz-in., the correction system must be capable of removing or adding material to within an accuracy of less than 0.04 oz-in. With an allowable correction tolerance in mind, various possibilities for a correction method can then be considered.

One method of correction uses prepared weights in suitable increments. With this system, the required balancing tolerance, the maximum expected unbalance, and the number of different sizes of weights must be determined. If a reasonable number of weights (say 10 different sizes in increments of less than twice the allowable correction error) will cover the expected range of unbalance, then this type of system will do a good job. Such a system is employed in the balancing of some squirrel-cage type blowers used for automotive heating and air-conditioning, Fig. 14.

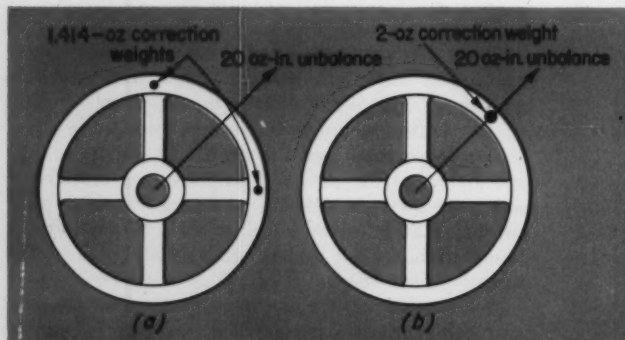

Fig. 13—Correction of unbalance using, *a*, single weight and, *b*, two weights 90 deg apart. Drilling radius is 10 in.

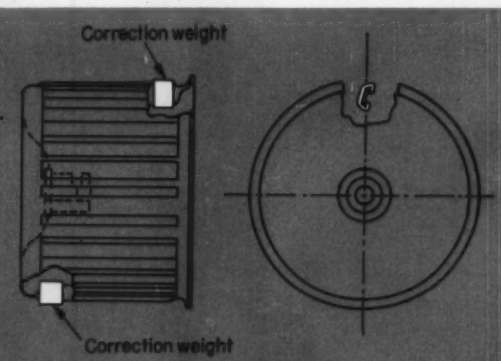

Fig. 14—Two-plane correction of unbalance in blower rotor using spring clips as balancing weights for incremental adjustments.

In this balancing procedure, the correction weights, which are spring clips of varying size, are snapped onto the blades of the blower while it is still in the balancing machine. Thus, the blower is in position to be checked after correction, if necessary, to determine whether or not the balancing tolerance has been met.

In addition to maximum expected unbalance and number of balancing weights, effect of tolerance on correction weights and possibilities for off-angle corrections must be considered in such systems. For many balancing jobs this type of correction system is a good solution. Such correction weights take many forms, such as clips on fan blades, washers secured with rivets or bolted in place, screws placed in previously tapped holes, weights pressed in reamed holes, lengths of extruded stock pressed in slots, etc.

When the number of weights for such a system becomes excessive, stock-size corrections no longer will serve the purpose. Weights of proper size can then be produced at the time of correction.

Solder strips can be cut to length and soldered to the part or strip stock can be cut and spot-welded in place. Such a system is infinitely variable in amount of correction and can be readily adapted to fully automatic balancing and correcting cycles.

Correction by removal of material from the heavy side of the part can also provide the same flexibility. Fig. 15 shows some of these methods. Hollow milling, for example, can be employed when other methods of material removal would seriously reduce the strength of a part with thin walls, or when holes through part walls are not allowable. Axial or radial feed, separately or in combination, can be used to control the action of the cutting tool and, thus, the amount of correction.

However, even these infinitely adjustable correction systems must provide a weight addition or removal to within tolerances. These tolerances result principally from the accuracy to which feed can be controlled and the part can be indexed. The effect of such tolerance on corrections is the same as the increments between the series of fixed-value correction weights mentioned previously, although the accuracy of the system is much greater.

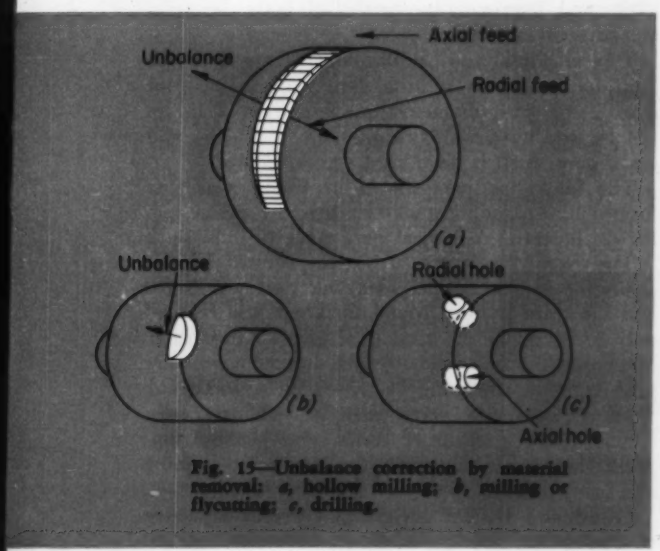

Fig. 15—Unbalance correction by material removal: *a*, hollow milling; *b*, milling or flycutting; *c*, drilling.

Correction by drilling out material is also a practical and widely used technique. The accuracy of metal removal in drilling is a function of hole diameter and depth, and drill-point shape. Hole size is dependent upon rigidity of equipment, drill wobble, and sharpness of the drill. A 1-in. drill, for instance, will produce holes from near size to 0.006 in. oversize, or larger if the drill is allowed to become excessively dull. Weight-removal calculations for the point of the drill assume a given angle of cone. Deviation from this angle will affect the correction accuracy not only because of the amount of material removed by the point but also because of the location of the center of gravity of this material.

The accuracy with which the depth of drill can be controlled varies widely with system and operator. As a general rule, however, the accuracy of drill-depth control which may be expected from quality equipment is: 1. Manual operation, $\pm 1/64$ in. 2. Mechanical trip, ± 0.005 in. 3. Hydraulic trip, ± 0.003 in.

Because of these sources of drilling error, about the best that can be expected from this method of correction is a 10:1 reduction in unbalance for any single-correction operation.

In general, because of similar accuracy limitations, an unbalance reduction of about 20:1 is the maximum practical single-correction operation that can be expected with any method. With extremely accurate equipment and rigorous control in all phases of the correction procedure, reductions of 50:1 and even more have been accomplished. But such procedures fall in the category of laboratory methods and are not often applicable in production.

The maximum initial unbalance which may be expected can sometimes be estimated in advance by considering the various contributing sources, such as eccentricity. Other factors, such as lack of homogeneity and extent of core shifts, are difficult to predict. Experience with similar parts that are similarly produced is the best basis for an estimate.

Evaluation of these factors in the design stage will indicate what procedures are possible and which will be most economical from the standpoint of design and type of balancing and correcting equipment. When initial unbalance in the part requires, say, a greater than 15:1 reduction and drilling is the correction method which best fits the production setup, then a two-step measurement and correction procedure may be required. Such a procedure corresponds to rough and finish machining or grinding operations and is required for basically the same reasons. Relative cost of better control in production of the part so that initial unbalance will be less, cost of more accurate correction equipment, and cost of an additional measuring and correcting operation will all have a bearing on the final decision.

Part shapes and materials that can be formed and sized by

METAL EXPANDING

J. F. COLEMAN
Grotnes Machine Works Inc.
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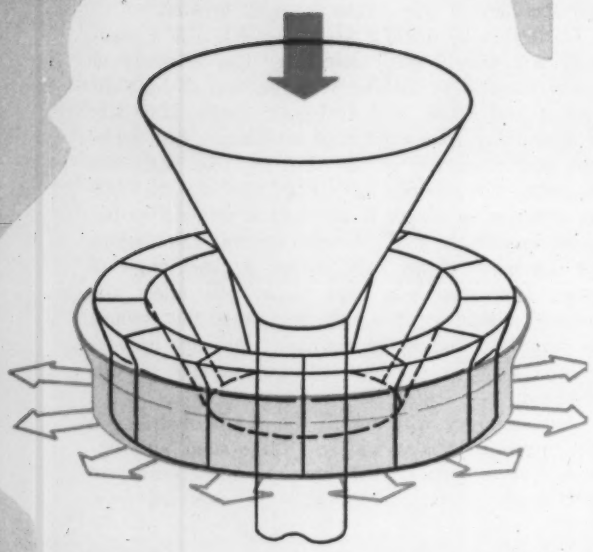

Principle of Expansion Forming

Basic elements of a metal expanding machine are a cone (actually a poly-sided modified frustrum of a pyramid), drawbar, jaws, table, and power system. The expanding machine uses the principle of the inclined plane or wedge. Mounted in a radially slotted table, the jaws are forced uniformly outward by the cone actuated by the drawbar.

A part to be expanded is placed over the jaws, or over dies fastened to the jaws, and is formed or sized when the outward jaw movement stretches the material beyond the yield point. The permanent set thus produced in the material permits precise control of final product dimensions.

Machines have been built in drawbar pull tonnages from 5 to 1580. A 2600-ton machine has been designed to handle as much as 80 sq in. (wall thickness × length) of steel having a yield strength of 50,000 psi. Special water-cooled jaws can be used to form heated parts which require hot dies. Machines with separate heads for each end of the part are used in automated production lines. Forming parts with one closed end can be done by pushing rather than pulling the cone between the jaws. Gapless heads are used when expansion ratios are high and gap marks can not be tolerated.

THIN sheet-metal forms, heavy forged and welded sections, and subassemblies can be processed by expanding. Final shape can be round, square, oval, polygonal, or irregular.

Heavy parts such as gear blanks, jet-engine rings, hydraulic cylinders, and large motor frames can be expanded to rough size to reduce machining time and material waste. Thin-wall parts can be formed to final shape. On subassemblies, expanding can eliminate distortions resulting from such assembly processes as bolting or welding.

Although expanding is not primarily used for weld testing, the process does automatically check weld strength. It has proved to be one of the best and most widely used methods for testing weld joints and improving properties of both the weld and adjacent material.

Typical Parts and Applications: Expanders are built to handle an infinite variety of shapes and sizes. Parts with diameters ranging from 2 in. to 144 in. and over, wall thickness up to $2\frac{1}{2}$ in., and lengths up to 20 ft have been accommodated.

The jet-engine part shown in Fig. 1 was first formed by expanding and then sized by expanding. Fig. 2 illustrates a flanged part made of mild steel.

Two expansion operations were required for the connector in Fig. 3. Deep-drawing steel was coiled and lap-seam welded. Metal thickness was reduced only 0.004 in. at the section of greatest expansion. Metal ductility and weld strength determine whether such extreme stretching as this will be successful.

Many jet-engine parts, such as exhaust cones, shroud rings, afterburner cones, and bearing supports, lend themselves to the expansion-forming and sizing process.

Coiled and welded steel rings are cold expanded to true-up and produce a correct circumference and

also to check welds. Automobile, truck, and tractor tire rims have been processed in this manner for many years.

Other products that are entirely or partially processed on expanders are blower casings, electric motor housings, heater tanks, automotive and marine mufflers, compressed-air tanks, and refrigerator and freezer cabinets.

The expansion process has also been successfully employed in the assembly of two or more parts by expanding one part into the other and then expanding both sufficiently to produce a permanent set. Parts assembled in this manner can either be used as they come off the expander or bolted or welded together when additional strength is required.

Materials: Practically any metal can be expanded to a definite form or size consistent with its mechanical properties. Expansion of welded shapes also requires certain properties in the weld and adjacent area to prevent rupture. On some parts the weld should be work-hardened first by roll-planishing.

Probably 95 per cent of the expansion process is devoted to steel and its many alloys. Mild steel produces excellent results. Vitreous-enameling iron is also processed by expansion. Some types and grades of cast iron can be expanded for sizing purposes.

Copper, aluminum, and titanium are the nonferrous metals most generally formed or sized by expansion.

Expansion Limits: Where does the metal come from to allow for expansion and change in shape of the part? Cold flow over the face of the machine dies allows metal to be drawn from the entire body of the part, thus avoiding any local thinning or weakening. Extensive forming may require several operations to produce the desired shape. Although cold-forming generally results in improved mechanical properties, simple annealing between operations can eliminate any difficulties if the part work-hardens.

Carefully controlled techniques have permitted a 60 per cent expansion in mild-steel butt-welded parts. In sizing heavy rings, the expansion necessary is usually 1 per cent of the diameter, although it can range up to 8 per cent. Forming light sheet-metal parts results in 1 to 2 per cent stretch at intermediate locations with as much as 20 or 30 per cent localized stretch.

Of course, ductility and other basic properties of a particular metal, as well as weld strength, will determine the ultimate stretch limits.

Part Tolerances: On small diameters of 3 to 5 in., tolerances of ± 0.001 in. can be maintained. For diameters in the 40 to 50 in. range, tolerances of ± 0.015 in. are generally acceptable; however, greater precision can be obtained when necessary. These tolerances would also apply to polygonal surfaces and radii.

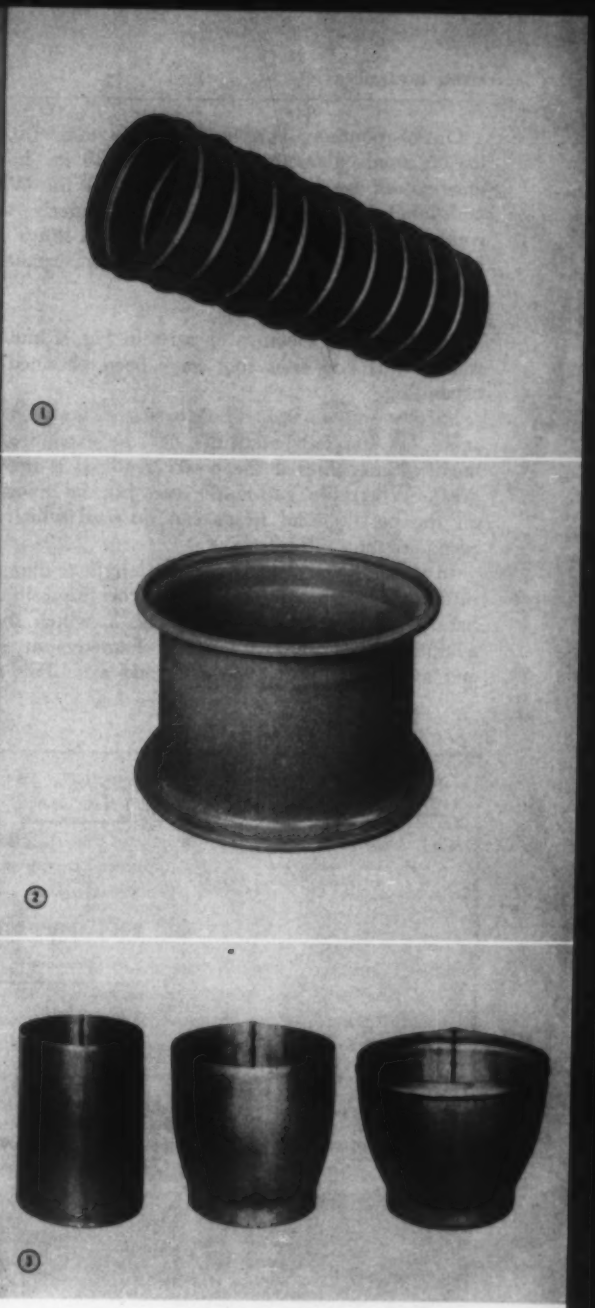

Fig. 1—Beaded jet-engine component, formed and sized. Diameter, 10 in.; length, 30 in.; stainless steel.

Fig. 2—Furnace fire-box component, formed and sized. Outside diameters of flanges, 24¾ in. and 25¼ in.; inside diameter of body, 20¾ in.; length, 14¾ in.; thickness, 20 gage; mild steel.

Fig. 3—Connector formed and sized in two operations. Original diameter, 9⅞ in.; final diameter of top, 15 in.; final diameter of bottom, 10 in.; original length, 12¾ in.; final length, 11⅜ in.; thickness, 0.035 in.; mild steel.

Out-of-roundness can be held to within ±0.001 in. on small diameters. Parts 20 to 30 in. in diameter can be held to within ±0.004 in. When additional accuracy is required, particularly with complex shapes, outer dies or hold-back rings can be used in conjunction with the inner expanding dies.

Part Shapes: Drawings of parts in Fig. 4 indicate some forms and sizes that have been obtained by expanding.

Parts with one end closed or with diameters too small for standard machines can be expanded on modified machines if the power required is not too great. When die gap-marks can not be tolerated on the part, special heads can be used which incorporate the gapless feature.

In general, parts with a great length-to-diameter ratio present difficulties and may be impossible to handle. An example of this is Fig. 5, which shows a thin-walled tube with offset diameters at each end and with flutes along the long axis. This part could possibly be made by a special combination machine, but the cost would be prohibitive unless extremely high production rates and a great number of total parts were required.

Another type that is often impractical, if not impossible, to expand is shown in Fig. 6. The steep angle *A* makes some sort of hold-down device necessary for the expander dies. This would considerably complicate the machine and materially increase the cost.

Production Rates: For light-duty mechanical expanders, production rates generally range from 200 to 700 parts per hour. The heaviest hydraulic expanders operate at 1 to 2 cycles per minute. More general-duty hydraulic machines, such as used for jet-engine parts and pipe couplings, operate from 2 to 6 cycles per minute. Higher or lower rates are available.

Double-ended expanders can expand 900 rims per hour. Bead expanders used by certain pail manufacturers can automatically form two-thousand 11¼ in. diameter by 13½ in. long shells per hour.

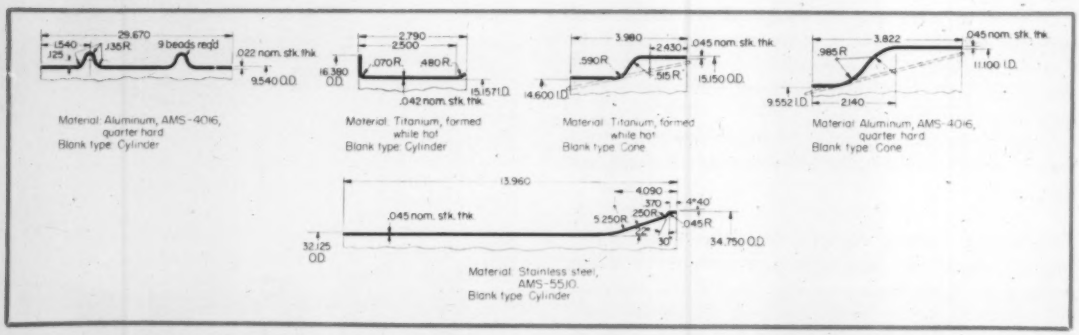

Fig. 4—Typical dimensions and materials of parts formed and sized, or just sized, in one expanding operation. Blanks for these parts were coiled and welded; outlines of cone type blanks are indicated in dotted lines. Width of a blank is determined by contour of the part; diameter is determined by spring-back of the material.

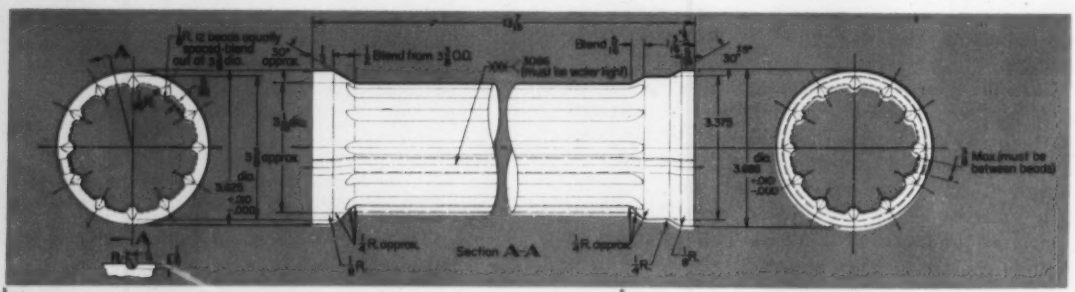

Fig. 5 (Above)—Small inside diameter combined with length of this part make it impractical to form by expansion. In addition, the flutes must be pressed in by "shrinking" action, which further complicates the machine set-up.

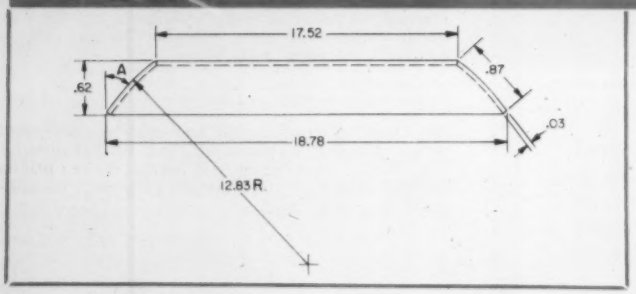

Fig. 6 (Left)—Short parts with extreme flare, indicated by this drawing, are also impractical to form by expanding without involved tooling.

Selecting Hydraulic Pipe

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WHEN power for hydraulic operation and control is supplied by a centralized power source, the hydraulic circuitry often involves lines which are long, straight, and semipermanent in nature. This is only one application for which threaded hydraulic pipe is best suited.

Pipes are rarely, however, the only type of line used in a single circuit. Therefore, a rational analysis of size and type of pipe required for an efficient combination is essential. This fourth article in a planned program on hydraulic lines presents design information on pipe sizes and strengths which help in selecting the right pipe for the job. In addition, a checklist of applications for which hydraulic pipes are recommended is included as a guide to proper application.

Nominal Pipe Size

Outside pipe diameters always conform to the corresponding series developed for pipe threads. For this reason, the outside diameter of each nominal size must remain constant, regardless of the wall thickness. Pipe sizes are designated by a nominal dimension. Originally, this dimension indicated the inside diameter of the pipe. However, the recent development of several wall thicknesses has destroyed the original meaning, since the outside pipe

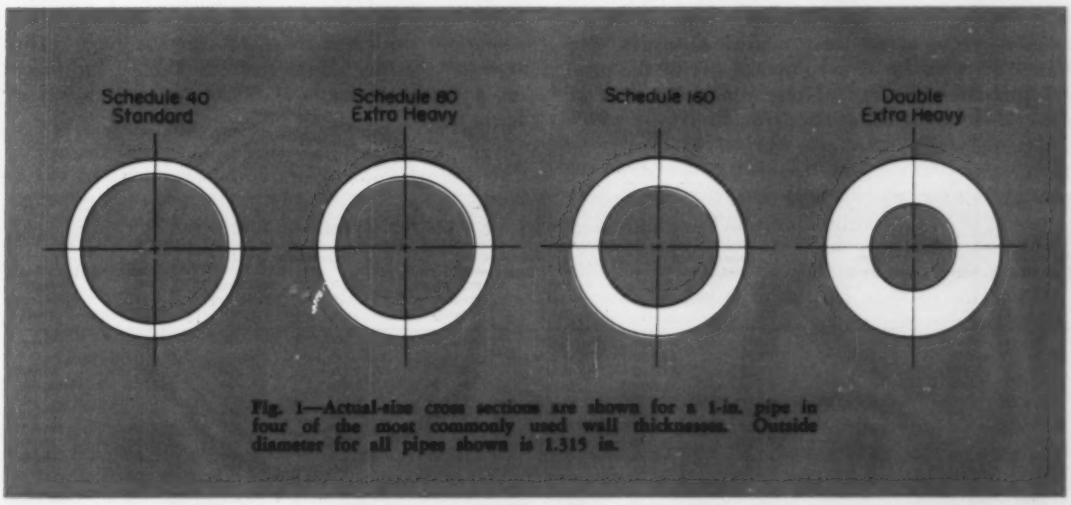


Fig. 1—Actual-size cross sections are shown for a 1-in. pipe in four of the most commonly used wall thicknesses. Outside diameter for all pipes shown is 1.315 in.

diameter is retained to conform to pipe thread series. Hence, variations in the wall dimensions were made by changing the inside diameter, Fig. 1.

Under the present designation system, the nominal pipe size is approximately equal to the inside diameter of Standard or Schedule 40 pipe, but varies considerably for pipe with any other wall thickness. The inside diameters and nominal sizes for pipes which are recommended for application in hydraulic systems are shown in Table 1.

Wall Thickness

Until recently, wall thicknesses for pipes were classified by the relative weight designations of Standard, Extra Heavy and Double Extra Heavy. However, a designation according to Schedule Number is currently growing in use. The Schedule Number is equal to the approximate value of the expression:

$$\text{Schedule Number} = 1000\,\frac{p}{\sigma}$$

where p = internal pressure, psi; and σ = material strength, psi. This relation is not used, however, for any calculation purposes.

Ten schedule numbers are distributed between 10 and 160, and the higher the schedule number, the thicker the pipe wall. The only series which are fully developed and which are in hydraulic system applications are: Schedule 40 which is practically identical to the former Standard designation, Schedule 80 which is practically identical to the former Extra Heavy designation, and Schedule 160 which is somewhat lighter than the former Double Extra Heavy designation. Other schedule numbers are for large-diameter pipes used in water and gas distribution systems. The wall-thickness tolerance for all commercial quality pipes is ±12 per cent of the nominal dimension.

To completely designate a certain pipe size, two dimensions are necessary: Nominal pipe size and wall thickness, expressed as a Schedule Number or by a weight designation. However, both of the dimensions required are only relative measures, and do not describe the actual physical size of the pipe. Interpretation in terms of pipe dimensions can be obtained from tables such as Table 1.

Working Pressures

Selection of the proper wall thickness for a certain working pressure depends on the diameter of the pipe and the operating conditions of the system. These operating conditions are expressed in terms of the frequency and magnitude of pressure shocks. Conventional wall-thickness calculations for pipes are based on the equation

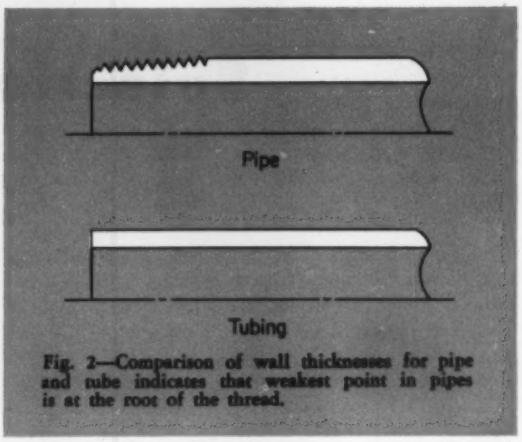


Fig. 2—Comparison of wall thicknesses for pipe and tube indicates that weakest point in pipes is at the root of the thread.

$$t = \frac{p_w\, d_o}{2}\left(\frac{M}{\sigma}\right)$$

where t = wall thickness, in.; P_w = working pressure, psi; M = safety factor; and σ = tensile strength, psi. Safety factors commonly used for various operation conditions are:

- 6 for noncritical applications where hydraulic shocks, mechanical vibrations, and additional stress are nonexistent.
- 8 for average system conditions, and for installations which must conform to JIC specifications.
- 10 for systems where considerable pressure shocks and/or mechanical abuse is anticipated.

Tensile strength for commercial quality pipe varies from 40,000 psi for low-grade and welded types up to 70,000 psi for high-grade seamless pipe. The bursting pressure values given in Table 1 are based on a tensile strength of 50,000 psi and a safety factor of one.

Table 1—Dimensions and Characteristics of Pipe for Hydraulic Systems

Nominal Pipe Size	Pipe OD	Threads per Inch	Schedule 40 Standard		Schedule 80 Extra Heavy		Schedule 160		Double Extra Heavy	
			Pipe ID	Bursting Pressure	Pipe ID	Bursting Pressure	Pipe ID	Bursting Pressure	Pipe ID	Bursting Pressure
(in.)	(in.)		(in.)	(psi)	(in.)	(psi)	(in.)	(psi)	(in.)	(psi)
¼	0.540	18	0.364	16,000	0.302	22,000	—	—	—	—
⅜	0.675	18	0.493	13,500	0.423	19 000	—	—	—	—
½	0.840	14	0.622	13,200	0.546	17,500	0.466	21,000	0.252	35 000
¾	1.050	14	0.824	11,000	0.742	15,000	0.614	21,000	0.434	30,000
1	1.315	11½	1.049	10,000	0.957	13 600	0.815	19,000	0.599	27,000
1¼	1.660	11½	1.380	8,400	1.278	11,500	1.160	15,000	0.896	23,000
1½	1.900	11½	1.610	7,600	1.500	10,500	1,338	14,800	1.100	21,000
2	2.375	11½	2.067	6,500	1.939	9,100	1.689	14,500	1.503	19.000
2½	2.875	8	2.469	7,000	2.323	9,600	2.125	13,000	1.771	18,000
3	3.500	8	3.068	6,100	2.900	8,500	2.624	12,500	—	—

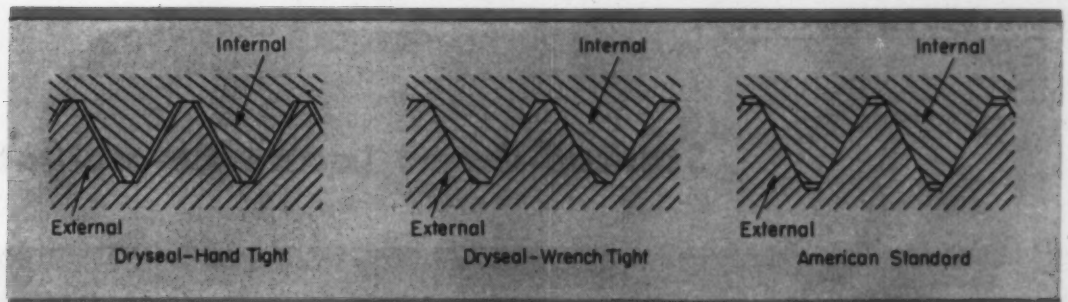


Fig. 3—Typical pipe threads.

Application Recommendations

Early hydraulic systems were often designed in accordance with established water and gas-line installation practices. Pipe threads and fittings for water and gas service lines were adapted in hydraulic system designs. At the time, these practices were satisfactory.

But as the result of increases in quality of other system components, the following shortcomings of the old practices have become more apparent:

1. The choice of wall thicknesses in the present pipe series is very limited with respect to present hydraulic system requirements. The necessity for rounding off calculated values to the next higher wall thickness manufactured often results in an unnecessary increase in material weight.

2. Burst-pressure calculations must be based on the weakest point in the pipe. This weak spot is usually the root diameter of the pipe thread. Therefore, the effective wall thickness of a pipe is decreased and considerable pipe material is virtually unused, Fig. 2.

3. Because of the larger wall thicknesses, piping systems are almost never fabricated by bending. Hence, many elbow fittings must be used. This increased use of fittings results in more potential leak points and higher resistance to fluid flow.

Despite these disadvantages, pipes are, and can be, used properly in hydraulic systems. The following is a list of recommended principles to observe in applying pipes:

1. Use pipes when they can be connected directly to pipe-threaded connections on system components.
2. Use pipes only when disassembly is improbable or infrequent.
3. Use pipes in systems when large volumes of fluid must be handled or when the line is long.
4. Use pipes for straight connections. Avoid pipe bending. Use radius of five times outside diameter if bending is necessary.
5. Use Schedule 40 pipe for air circuits, noncritical low-pressure hydraulic applications and when stresses or shocks are absent.
6. Use Schedule 80 pipe for medium and medium-high pressure applications, and for average conditions.
7. Use Schedule 160 pipe for high-pressure applications. For these applications, recheck calculations to make sure that the smallest wall thickness is sufficient.

Pipe Threads

Pipe can be connected directly to other components to form leakproof joints because of the sealing effect produced by the pipe threads. Two general pipe-thread types have been developed; the taper pipe thread, and the straight pipe thread. Both types are essentially the same. The main difference between these types exists in the ¾ in. taper per foot of diameter placed on the taper-type thread. Pipe threads are specified by the nominal pipe size on the OD of which the pipe thread will fit.

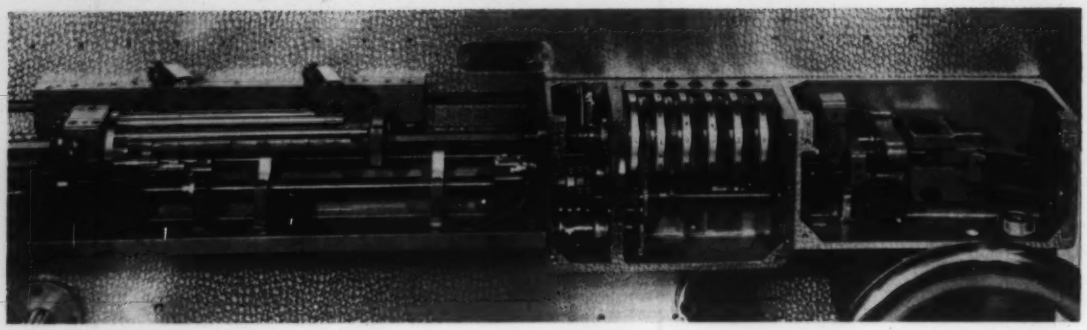
There are two types of tapered pipe threads which have been standardized. The American or National Standard Taper Pipe Thread (NPT) seals by flank contact in the treads and requires sealing compound to prevent leakage around spiral clearance in the thread roots, Fig. 3. In the Dryseal American or National Taper Pipe Thread (NPTF), the roots and crests engage before the flanks come into contact, and forced tightening results in a destructive seal along the crest contact. Hence, sealing compound is not necessary on Dryseal threads. However, to prevent galling of the threads, some lubricant or lubricating thread compound should be used. The NPT and NPTF threads are interchangeable, but the dry-sealing property is effective only when both mating threads are of the Dryseal type. The NPTF type of thread is required by the SAE and JIC Standards and is used on most fittings.

Straight pipe threads of the American or National Standard Straight Pipe Threads for Mechanical Joints (NPSM) are used mainly for mechanical connections. These threads are used for certain pipe connectors such as union fittings.

Pipe-thread connections should be made with 2/3 of the thread length engaged. Burrs should be carefully removed from the thread end to eliminate the possibility of flow obstructions or fluid contamination. Thread sealer is applied only to the middle portion of the thread to prevent the sealant from entering the fluid system.

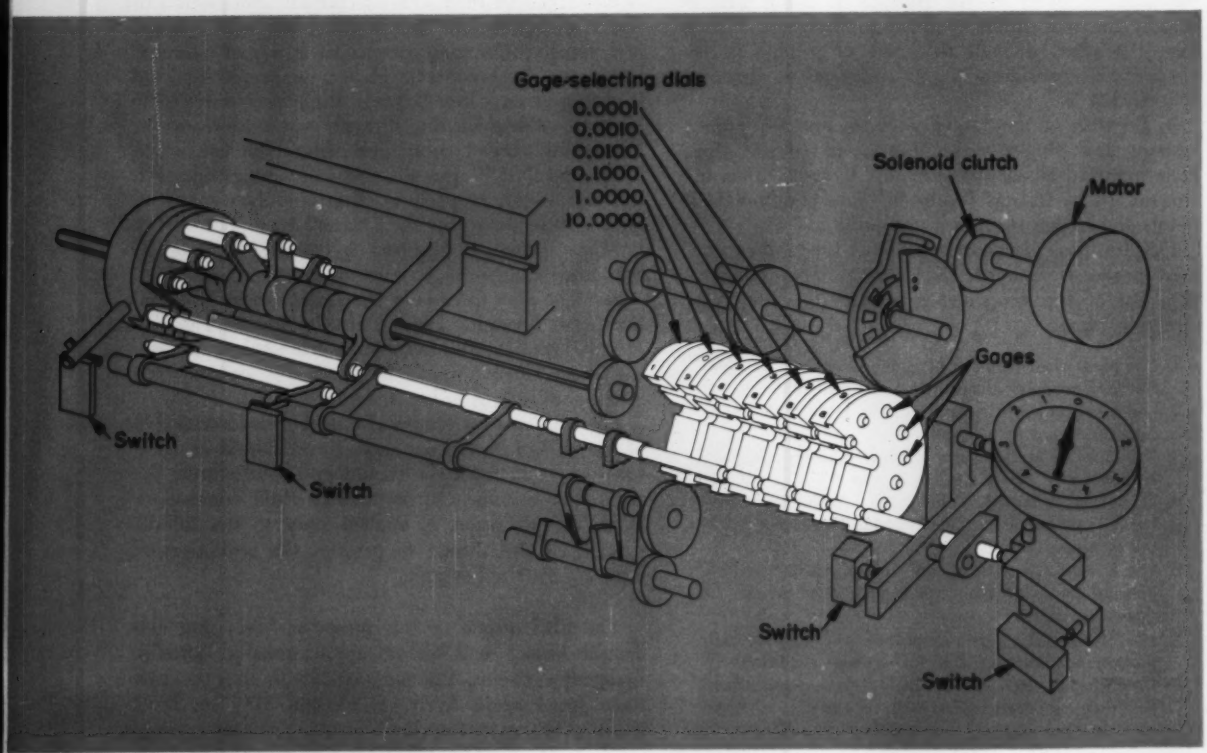
The fifth article in this program, "Selecting Hydraulic Hose," will discuss applications of hoses to hydraulic systems. Previous articles in this program have appeared in April 16, 30, and May 14, 1959, issues of MACHINE DESIGN.

Stacked Gages Locate Co-ordinates



CO-ORDINATE DIMENSIONS are established in a new Fosdick numerically controlled jig borer by automatic linear stacking of Class A gages. Gage stacking is accomplished in a totally enclosed measuring unit in the machine. The dimension required in each co-ordinate direction is set by the operator on six direct-reading digital dials or on a tape-controlled console. These dials enable the operator to set any dimension within the capacity of the machine in increments of 0.0001 in.

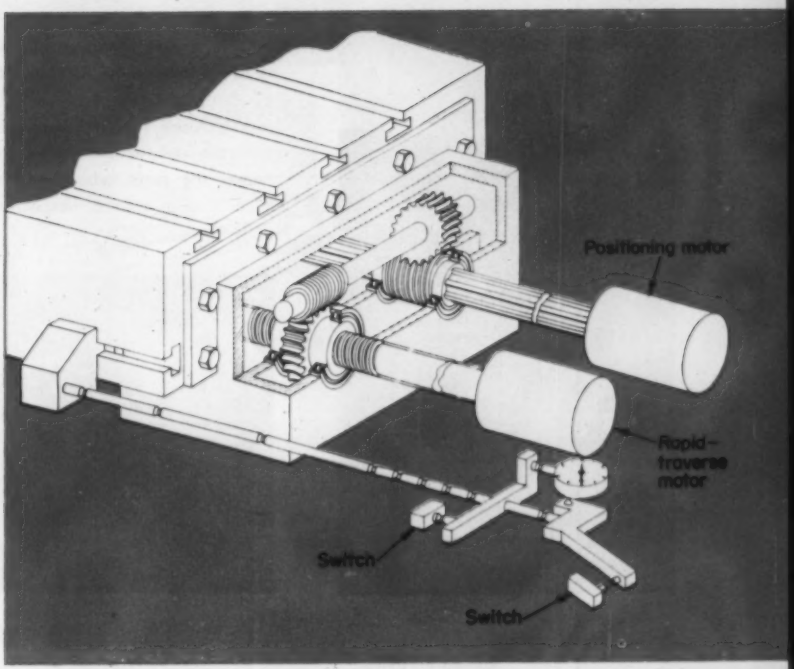
Decimal dimensions are controlled by four dials. Each dial contains ten gages which are free to move axially in a turret-type arrangement. Whole-number dimensions are controlled by the other two dials. One of these dials brings in gages from 1 to 10 in. in length, providing dimensional increments of 1 in. The second dial brings in 10-in. increment gages.

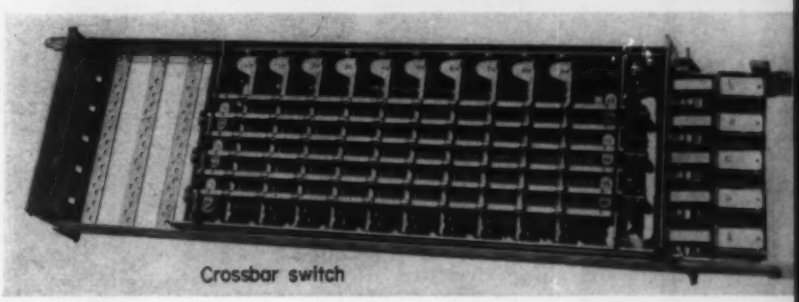


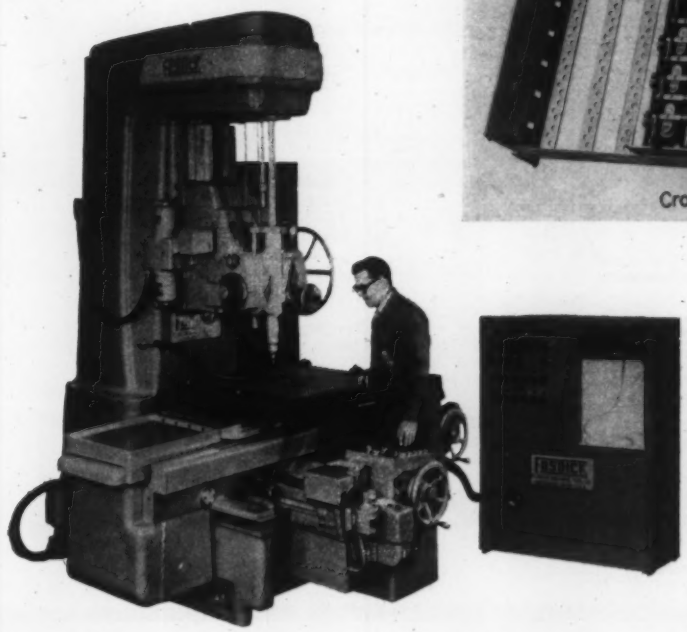
In Automatic Positioning System

AUTOMATIC POSITIONING of the table is accomplished with a two-speed traversing system. Assume a dimension is set on the numerical dials and the proper set of gages are brought into position. With the gages aligned, the operator depresses the automatic positioning button. If the table is at the left of the desired point, it moves to the right toward the switching mechanism at 136 in. per min, stacking the gages as it moves. When the gages are stacked, the last gage contacts an operating rod and, in turn, a bracket member which operates a rapid-traverse limit switch. This action stops the rapid-traverse motor and starts the positioning motor which moves the table at 7/16 in. per min through a two-stage worm and worm-wheel reduction gearbox.

Positioning accuracy of the system is controlled by the final positioning limit switch which has a repeatability of plus or minus 0.0001 in.




Crossbar switch

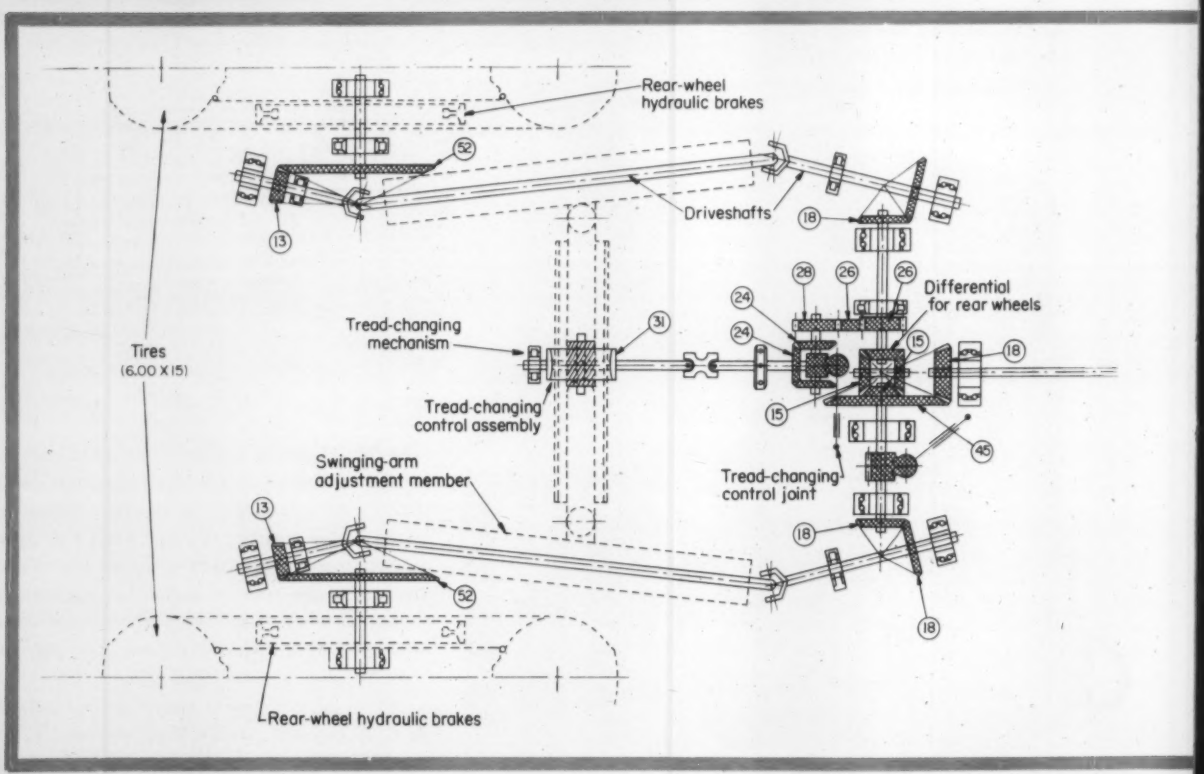


MEMORY STORAGE SYSTEM in numerical control console consists of plug-in crossbar switches and relays. All information for machine control is stored in two crossbar switches when two axes of motion and speeds and feeds are controlled. This use of the crossbar switch for information storage is a new application of standard telephone equipment which has been used only as a multicontact superselector switch.

Details of this control system were reported by C. R. Hibbard, Fosdick Machine Tool Co., at the 1959 Westinghouse Machine Tool Forum.

Vehicle Features Powered Front Wheel

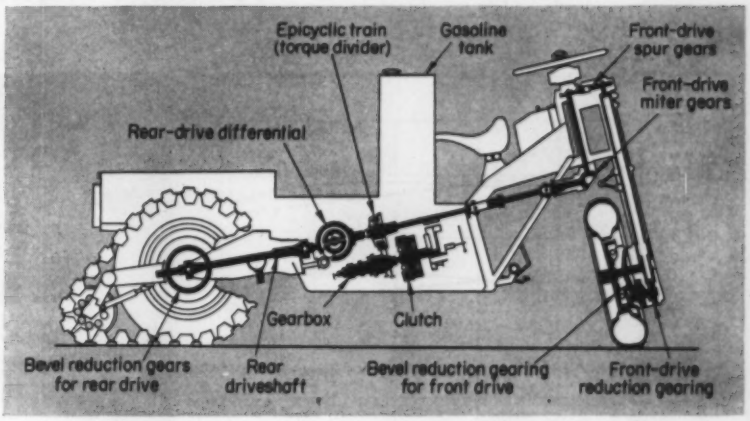
THREE-WHEELED DRIVE with track-laying units on rear wheels makes military vehicle highly suitable for travel in rough, mountainous terrain. Designed for the Italian army by General Garbari of Turin, Italy, the machine drive system includes two differentials. The central differential of epicyclic gear-train design divides propelling torque between the front wheel and the rear wheels at ratios of 1 to 5 and 4 to 5, respectively.



And Adjustable-Spacing of Rear Wheels

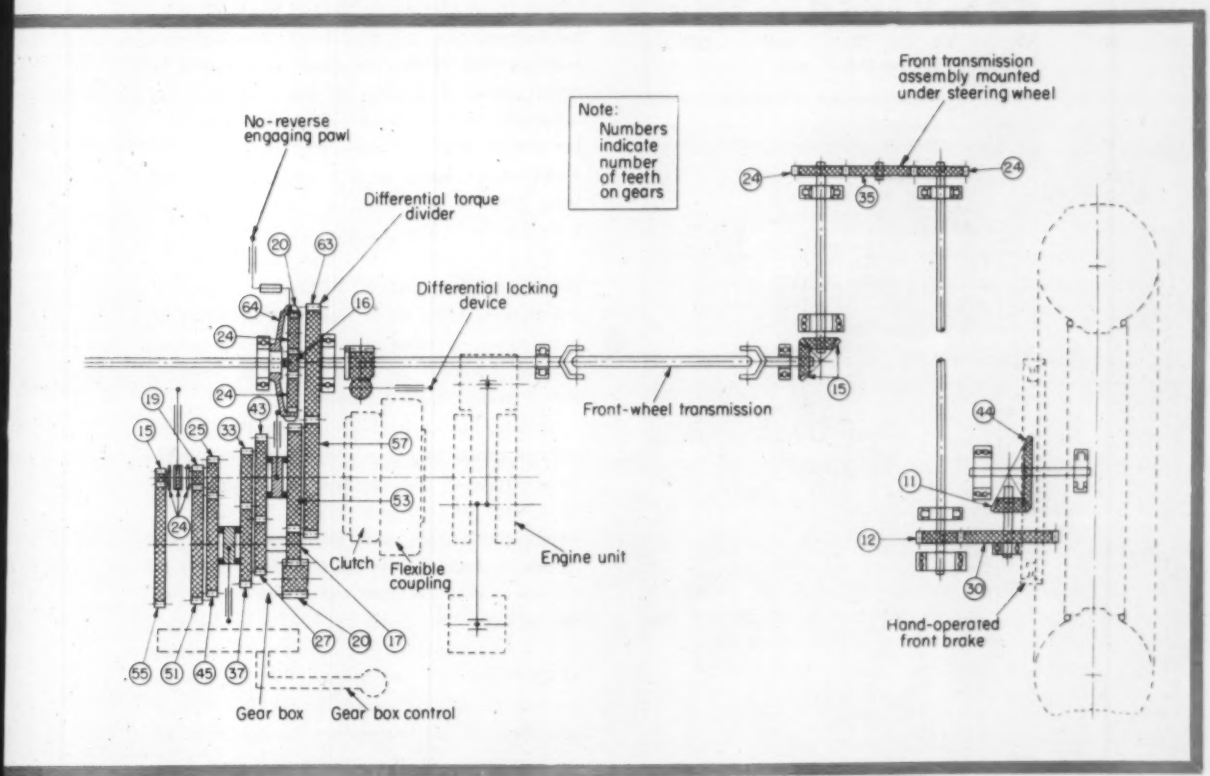
DRIVESHAFT IN STEERING COLUMN drives the front wheel, which is mounted on one side of the front column support. The front suspension is a telescoping design built with helical springs and hydraulic shock absorbers.

The steering wheel can rotate the front wheel through an angle of 90 degrees on either side of the vehicle centerline. Steering-wheel gear ratio is 4.5 to 1.

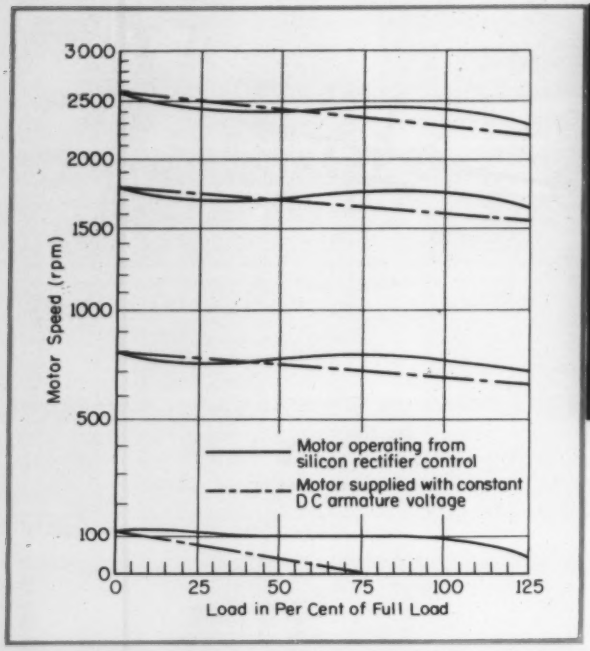


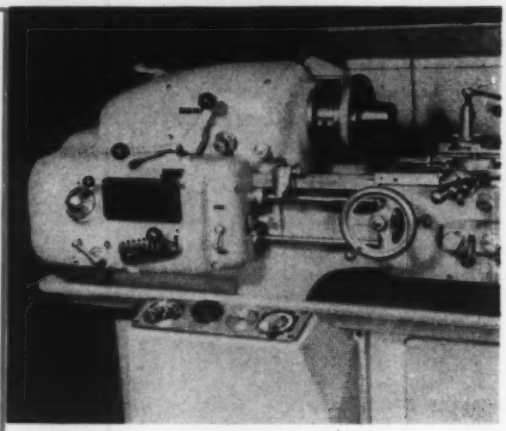
VEHICLE DRIVE POWER is produced by a two-cylinder engine which develops maximum power of 20.27 hp at a speed of 4200 rpm and maximum torque of 4.3 lb-ft at 2200 rpm.

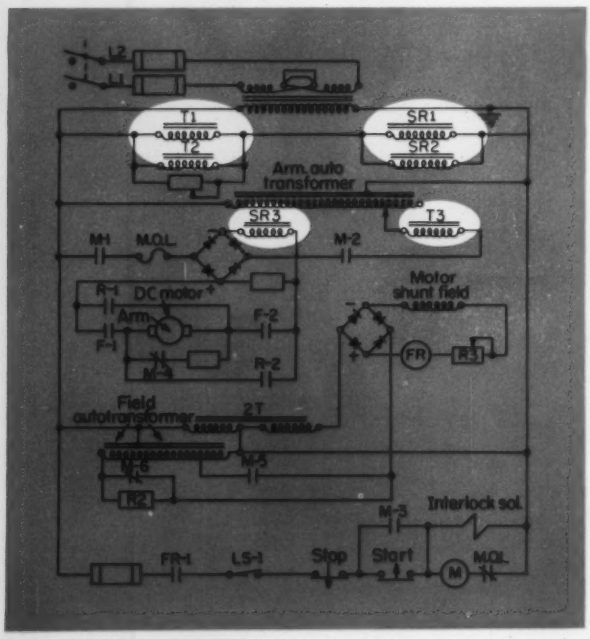
Known as the Army Mule, the vehicle is manufactured by Moto Guzzi, Mandello Del Lario, Como, Italy. It has six forward speeds and one reverse, giving a wide range of flexibility in power and speed.



Compensating Voltage in Rectifier Flattens Motor Speed-Torque Curves







ADJUSTABLE-VOLTAGE POWER SUPPLY designed with adjustable autotransformers and silicon rectifiers features good speed regulation. As reported by W. A. Means, project engineer, Barber-Colman Co. at the 1959 Westinghouse Machine Tool Forum, the circuit is designed to adjust speed of a 3-hp, dc shunt motor. The adjustable-voltage drive was built specifically for a 9-in. tool and gage makers lathe. The 120-v motor, rated at 650 rpm, is controlled from 2600 to 650 rpm by field control and from 650 to 65 rpm by armature control.

IR-DROP COMPENSATING VOLTAGE supplied to armature rectifier comes from the secondary of transformer winding T3. This compensating voltage increases as load increases, keeping motor speed almost constant.

Voltage output from T3 is controlled by the voltage across its primary windings, T1 and T2. This voltage, in turn, depends on the combined impedance of reactor windings, SR1 and SR2. Impedance of SR1 and SR2 depends on the current in their control winding, SR3. With no current in SR3, combined impedance of SR1 and SR2 is high. As motor loading increases, current in SR3 increases and combined impedance of SR1 and SR2 decreases. This change increases the voltage across T1 and T2. As a result there is an increase in voltage from T3, compensating for the additional motor load.

Correct interpretation of data from tests on materials properties often helps to improve designs. Which test to use, though, is often a problem. Here is a rundown on properties tests and their significance for . . .

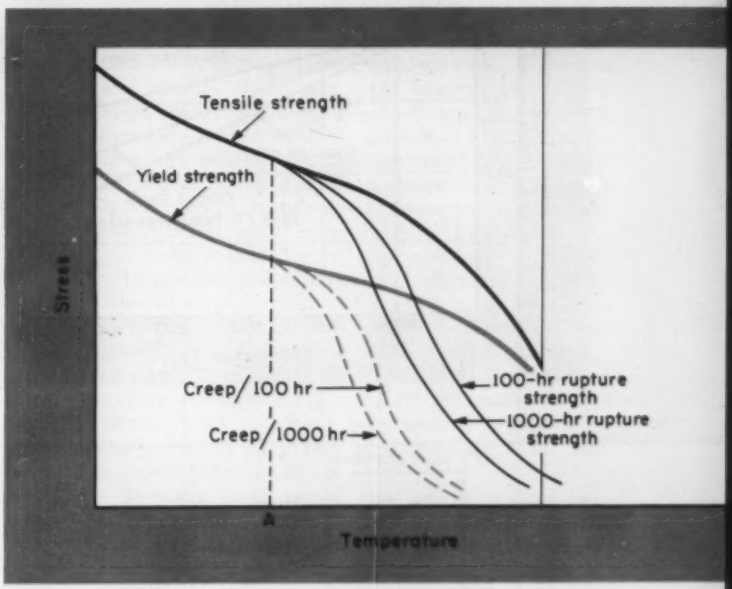


Fig. 1—Sensitivity of yield strength and tensile strength to temperature rise. Strength becomes time dependent at temperature *A* which represents approximately 40 to 50 per cent of the alloy melting point. Such data are used by designers to determine material limitations. The criterion for jet-engine design, for example, is generally 70 to 80 per cent of either yield strength or the 100-hr rupture strength.

Evaluating High-Temperature Materials

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THE old reliables—tensile ultimate and yield-strength properties—are not enough to evaluate materials for today's specialized uses. Designs have become more competitive in price, weight, size, and performance. Now, more than ever, the designer must know specifically how materials react in given environments. Environmental testing can only supply part of the answer. Although it tells how a part will act after it is made, it does not tell where to begin to design.

Such tests as creep, stress rupture, fatigue, and notch tensile, formerly limited to materials for critically stressed applications, have become today's standards. There are many details and refinements of these properties tests that are commonly overlooked. Here are some suggestions that should help get the most out of test data and aid in selecting an alloy suitable for loads and stresses encountered in service.

Tensile Properties: Yield strength rather than ultimate strength should be considered in design because it is a more realistic design criterion. If this fact is made known when test data are reported, data can be interpreted directly in terms of design requirements. Engine and airframe designers, for example, are using curves such as shown in Fig. 1 to determine material limitations. At temperature *A*, which corresponds roughly to minimum recrystallization temperature of the base metal, strength becomes time dependent.

Modulus of elasticity is an important design quantity because it indicates the elastic deflection in a

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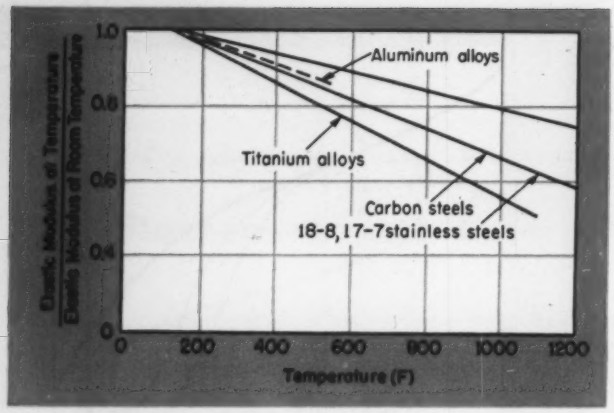


Fig. 2—Variation in elastic modulus with temperature for typical airframe alloys. The modulus is taken as the slope of the stress-strain curve at the origin.

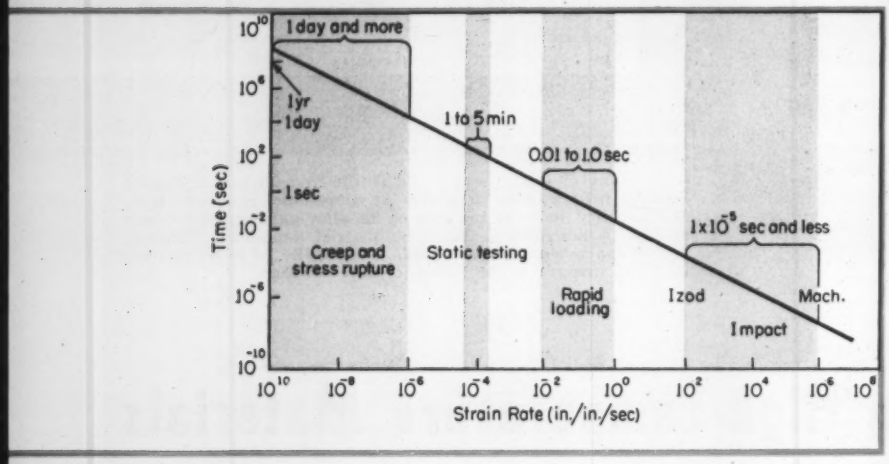


Fig. 3—Relation of rapid-loading strain rates to those developed with other methods.

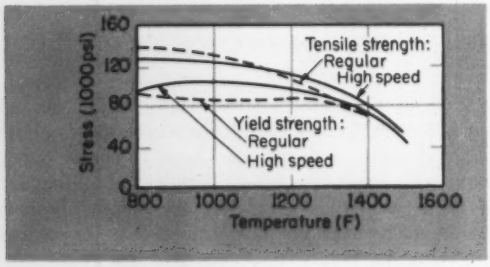


Fig. 4—Effect of high-speed testing on yield strength for precipitation-hardening austenitic steel, A-286, at elevated temperatures. Heating rate was 120 F per sec and loading rate 50 per cent per min.

geometric section. A high modulus is desirable for stiffness and a low modulus for shock absorption. Because most missile airframes are designed for loading which is so light that proof stress or yield stress cannot be developed, a high modulus is more important than high tensile strength. For this reason, many missile designers consider beryllium a favorable structural material even at strengths below 50,000 psi at 600 F.

At room temperature and elevated temperature the modulus is nearly constant for each alloy system, Fig. 2. However, at elevated temperatures, the value of the modulus of a particular alloy depends on whether it was determined statically or dynamically. The degree of accuracy required in the value of elastic modulus will dictate which test procedure should be followed. If ± 5 per cent accuracy is sufficient, then values obtained from the static stress-strain curves are adequate.

Transverse properties of forged metals, especially steel, should be compared after final heat treatment. Generally, steels which must be quenched and tempered for strength lose some of their directional properties. They usually have higher transverse ductility than the semiaustenitic steels which gain strength from precipitation hardening. Also, test data

on transverse properties are meaningless unless the materials are compared with equivalent forged reductions.

Sometimes, if the transverse ductility of a steel chosen for other properties is not sufficient, it may be improved (especially at very high tensile levels) by vacuum melting.

Compressive Strength: The fact that this property normally approximates tensile strength should not be taken for granted. Ideally, direct compression should not cause failure because deformation increases the area thereby relieving stresses. But practically, most compression failures originate from buckling of sheet fabrications.

Tensile strength is increased when metals are worked into sheet form, but compressive strength is not increased by the same amount. Compression properties in transverse directions also differ. Therefore, sheet materials, particularly in thin gages, should be stressed in tension, and cast materials should take compressive loads.

Strain Rate: In static testing, yield strengths at defined deformations or ultimate strengths are of interest. In long-time testing, a knowledge of the variation of deformation under load with respect to time and the time to cause fracture are important. Ratios of rupture stresses for these tests are, generally, about the same as the room-temperature ratios of ultimate strengths.

Problems with new weapons systems have aroused interest in short-time (rapid loading) tests. For orientation purposes, rapid loading should be considered with respect to other tensile testing, Fig. 3. Note that strain rates in fairly common use cover a range in which the ratio of the highest to the lowest is about 10^{15}. Standard testing speeds and rapid loading are both near the center of the spectrum, but the ratio of rapid-loading strain rates to standard rates is still about 10,000 or 100,000 to 1.

Neither the short-time tensile test nor the long-time creep test simulates conditions found in rockets and missiles where very rapid heating and loading rates are encountered. For such applications, it is necessary to determine the ultrashort-time properties of alloys with special test equipment. Some results are shown in Fig. 4. Here, high-speed yield strength of the steel is higher at all temperatures than the conventional yield strength. Also, high-speed tensile strength is higher at temperatures above 1100 F.

In general, strength values of alloys under conditions of rapid heating and loading are higher than those obtained with conventional, relatively slow tests. These higher values can be used in the design of short-lived missile structures. High heating and cooling rates involve a need for thermal-shock resistance, and tests have been devised to determine the sensitivity of materials to cracking when subjected to these conditions.

In effect, strain rate is how fast an applied load keeps stretching parts. Usually, a ductile part under load deforms and relieves the stresses on it. However, when stresses remain or are aggravated by the strain, they can raise or lower the strength of a given material. Slow strain rates, as in creep, lower the yield strength and ultimate strength. Rapid strain rates can raise these strengths to widen the range between and give more apparent ductility. Explosive forming, which takes advantage of this, successfully works metal which is too brittle for normal processes. In missile design where short-life instantaneous loads are combined with high deformation limits, design stresses well above the yield are allowable.

It is well to remember that before using yield-strength values, check the strain rate of the test. If it is not given or is in the wrong order of magnitude, further testing may result in better data.

Creep Strength: A more precise design criterion than rupture strength is the stress required to pro-

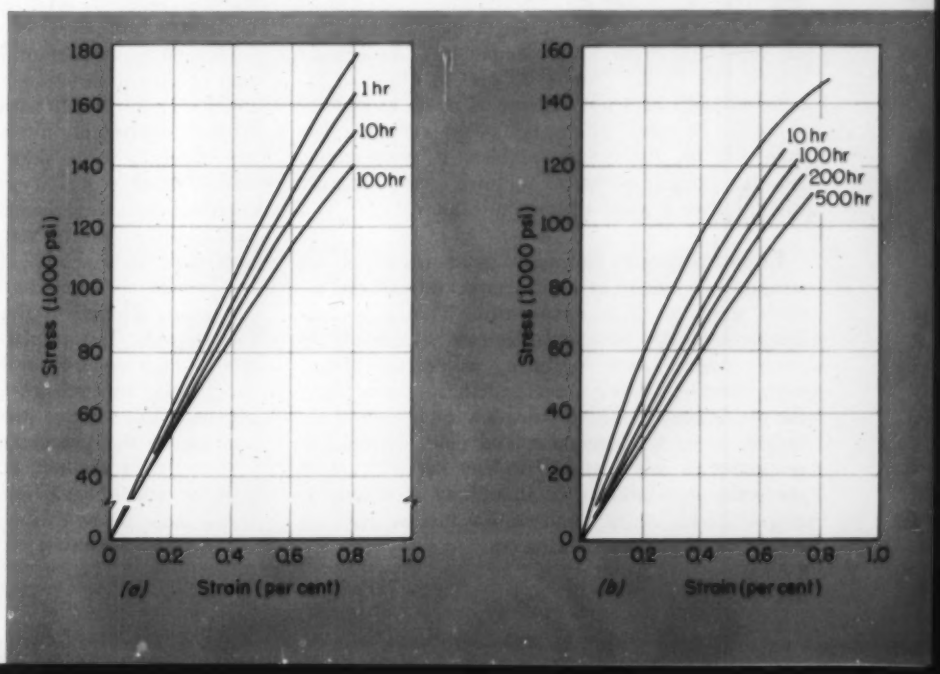


Fig. 5 — Isochronous stress-strain curves at 800 F. Materials are Crucible 218 sheet, *a*, tempered at 1035 F to Rockwell C 54, and Crucible 422 sheet, *b*, tempered at 850 F to Rockwell C 47.

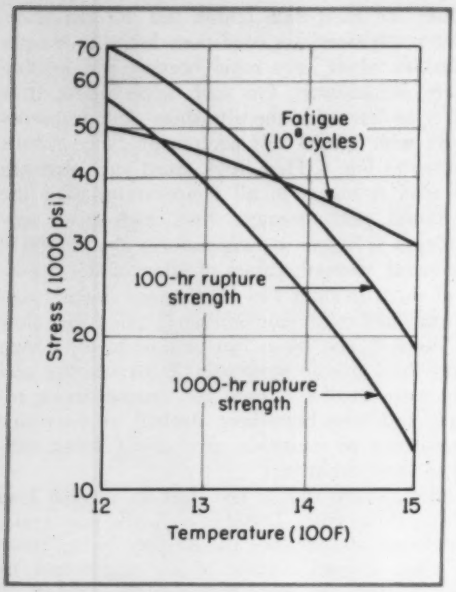


Fig. 6—Relation between fatigue and rupture strength for Inconel X blading alloy. Fatigue failure predominates at the lower temperatures as time to reach 10^8 cycles decreases.

duce a given strain in a definite time interval. Data of this type simplify the task of evaluating the effect of creep on design and can be presented in the form of constant-time (isochronous) stress-strain curves, Fig. 5. These curves are constructed from creep data by plotting the strain produced by different stresses at constant time. The relationship of isochronous curves to a stress-strain curve is such that the points at which the isochronous curves deviate from the straight line indicate the stresses at which creep becomes an important factor in design.

The relationship between fatigue failure and stress-rupture failure is shown in Fig. 6. While rupture and creep stress are still the limiting strengths at high temperature, fatigue strength may be less than the rupture strength at low temperatures for equivalent service times. This is because in alloying, fatigue strength does not increase as much as rupture strength. In cases where 10^8 cycles occur in less than 100 hr, the fatigue problem is more critical because fatigue strength is lower than rupture strength over a wider temperature range.

Fatigue Strength: Normally, structures which are adequate in fatigue at room temperature should remain sound at high temperature. This is because fatigue strength does not decrease as rapidly as tensile strength with increasing temperature. However, where short life permits design stresses above the yield point, the high stress-low cycle part of the fatigue curve is inconsistent and gives a spread of properties as much as 200 to 300 per cent. Here, the endurance-limit curve should be used only as a guide with more emphasis on further environmental testing of actual parts.

When cyclic stresses from thermal gradients are above the yield point, the high stress-low cycle part of the fatigue curve is again just as unpredictable. Although these stresses come from different causes, their effect is the same. Materials which resist thermal fatigue have low expansion and high conductivity. Large thermal stresses can be avoided by minimizing temperature gradients and matching expansion characteristics of adjoining sections of the same assembly.

For elevated-temperature design, it will probably be useful to consider creep and fatigue simultaneously. That is, a component may fail because of too much plastic flow or from fracture by repeated stress. In many instances, the only satisfactory method of obtaining actual stresses on components in the detail required for fatigue is to use strain gages on full-scale structural components.

Influence of Room-Temperature Properties: Good mechanical properties of materials at elevated temperatures cannot be realized if poor performance occurs at room temperature. One reason for poor performance would be inadequate preparation of the material during processing. Therefore, the designer must have appropriate test data to tell him if the material was adequately processed to meet design requirements.

Tests which measure notch sensitivity in different ways are used particularly for this purpose. For sheet materials, comparable procedures which examine the surface structure are equally important because surface condition governs performance to a great extent.

Tear Resistance: A property which has assumed new importance when materials are used at high strength levels is tear resistance. The philosophy of structural design termed "fail-safe" has been advanced as a safeguard against crack propagation. The fail-safe structure is one in which complete or obvious partial failure can occur to a principal structural member without resulting in a complete collapse of the structure.

One of the important factors in evolving the design of such a structure is the choice of proper material. Those which withstand cracks and damage without appreciably affecting their over-all strength are naturally more desirable than those in which minor damage has a pronounced effect. It has, therefore, become a standard practice to test all new materials for tear resistance at low and high temperatures.

The tear-resistance test predicts how fast a crack propagates through a given material once the crack has started. Test results shown in Fig. 7 indicate that a high ductility or low ratio of yield strength to ultimate strength gives a high value of tear resistance. But relative merits of steels also differ according to the proportion of length to width. If tear-test data are not available, choose a material with a ratio of yield strength to ultimate strength below 0.85. below this value, inherent ductility minimizes notch sensitivity.

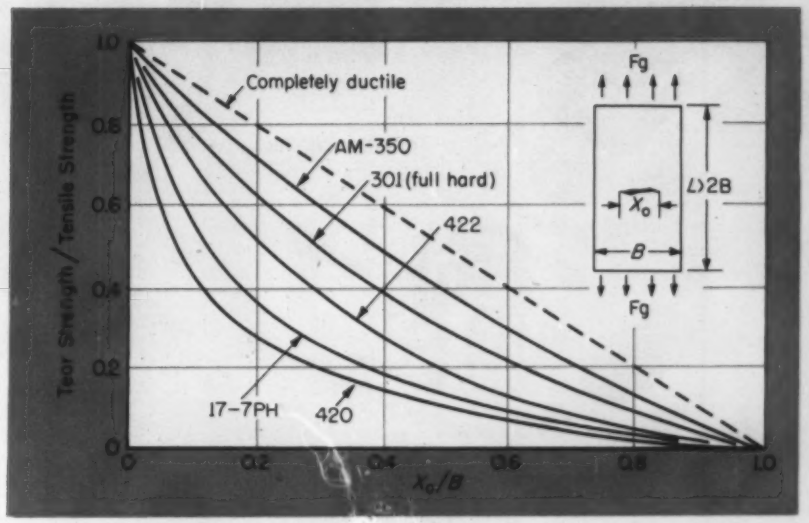


Fig. 7—Tear resistance of various stainless-steel sheets for panel width, *B*, of 9 in.

Biaxial Stresses: These stresses, such as occur in pressure vessels for the missile industry, can be simulated by hydraulically testing cylinders. Resultant data have shown that uniaxial tests cannot predict biaxial performance. Many steels when hardened to above 200,000 psi ultimate strength exhibit brittle failure at stresses below their uniaxial yield strength. In biaxial tension, elastic modulus varies with load, and a steel may reach a higher stress before a given deformation or strain occurs. Therefore, designs should have more ductility when stresses act in more than one direction. Often, the same steel at a lower strength but with more ductility will do the job better.

General Considerations: Surface defects, such as decarburization from hot rolling and heat treatment, must be avoided because they lower the tensile strength in sheet below 0.020 in. thick. At 0.040 in. or above, tensile strength is not lowered, but fatigue strength can still be reduced by as much as 40 per cent. This is especially pronounced in the hot-work type steels now being considered for ultrahigh-strength structures. Contrary to common belief, removing surface defects in sheet metal by grinding does not lower fatigue strength. The many fine scratches distribute the stress concentration of each individual notch.

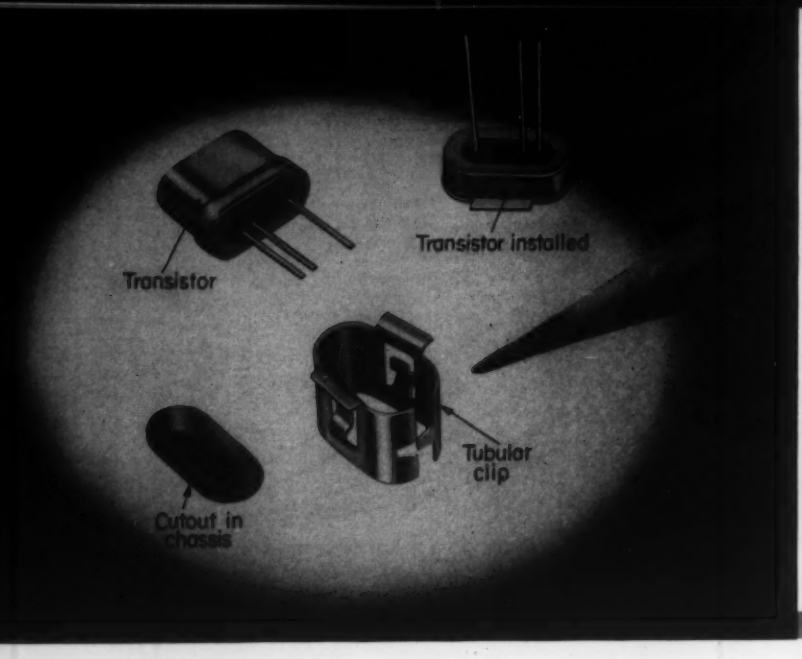
While austenitic stainless steels do not decarburize in oxidizing atmospheres, they absorb carbon from reducing atmospheres and lose both corrosion resistance and ductility. In a given subassembly, similar steels should be used so that the same heat treatment serves for all. This lowers cost and reduces chances of shop errors. It also avoids thermal expansion mismatch which builds up stresses.

The statistical nature of mechanical properties of materials and the importance of determining the variance in these properties is, unfortunately, not well recognized. In searching through metallurgical literature, the designer often finds that information is presented as "mean" or "typical" values. He cannot use these values since, in designing, he must use the lowest strength value that can be expected. Therefore, he is forced to apply a safety factor so that the design will have a reasonable certainty of success. As a result, the design suffers a heavy weight penalty because of the uncertainty of the accuracy and value of the data. Guaranteed minimum values should be required.

They Say . . .

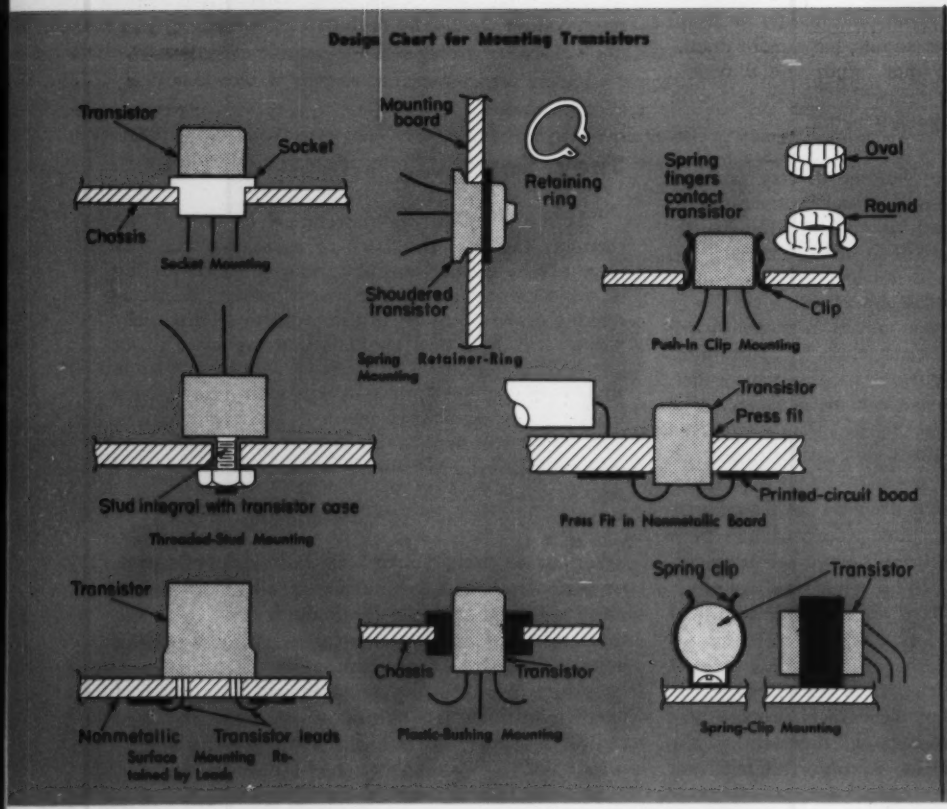
"As the complexity and technical content of the economy increase, the work of managing will perforce require greater sensitivity to and understanding of the technical considerations. Moreover, decision-making draws on many of the problem-solving techniques and analytical methods that are basic to an engineering education. Therefore, it is inevitable that more engineers and scientists with aptitudes for managing work will be needed, both in numbers and per cent of total."—H. W. GOULDTHORPE, *manager, engineering personnel service, General Electric Co., New York, N. Y.*

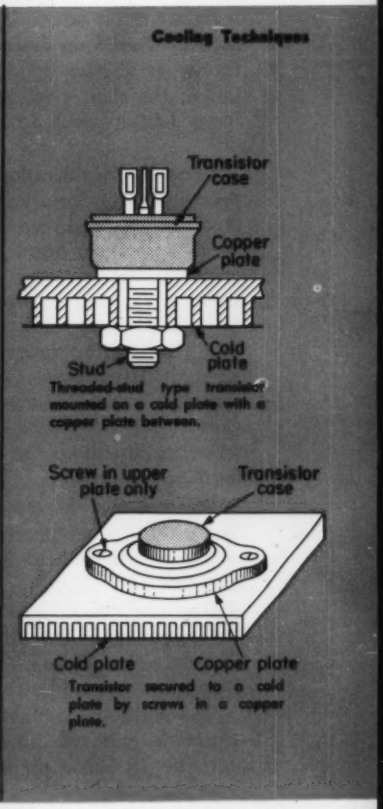
" . . . as designers we can fail to benefit from research if we treat its results with a lack of creative imagination. If we take its products and try to use them solely as replacements for everyday items, we are not designing for the future. We are not properly using research. We must develop an inspired creative attitude for putting to use the new and radical developments research is turning out daily." —SAMUEL L. FAHNESTOCK, *chief industrial designer, Aluminum Co. of America.*



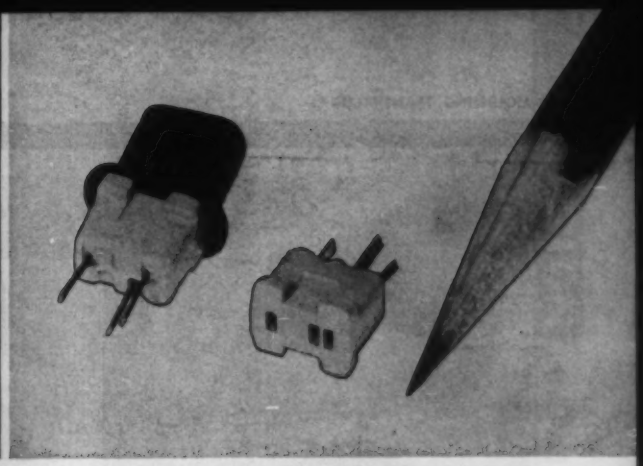
Push-in vibrationproof clip is designed to hold a transistor securely, yet it permits easy removal of the transistor. In assembly, the transistor is placed in the Tinnerman Products Inc. clip, and the two units are pushed into a cutout in the chassis. Spring fingers in the clip lock in place and also grip the transistor.

HOW TO MOUNT TRANSISTORS




Cooling Techniques
Transistor case
Copper plate
Cold plate
Stud
Threaded-stud type transistor mounted on a cold plate with a copper plate between.
Screw in upper plate only
Transistor case
Cold plate
Copper plate
Transistor secured to a cold plate by screws in a copper plate.

Shock-absorbing plastic mounts for small transistors. Designed to push into 7/16-in. diameter holes, these Delbert Blinn Co. mounts are made for several different transistor sizes and shapes.



Mica-filled phenolic sockets from Cinch Jones Mfg. Corp. simplify mounting of low-power transistors. These sockets slip into rectangular holes in the chassis or printed-circuit board and are held in place with spring-steel retainers.

. . . on printed-circuit boards and electronic chassis

FRANK WILLIAM WOOD JR.
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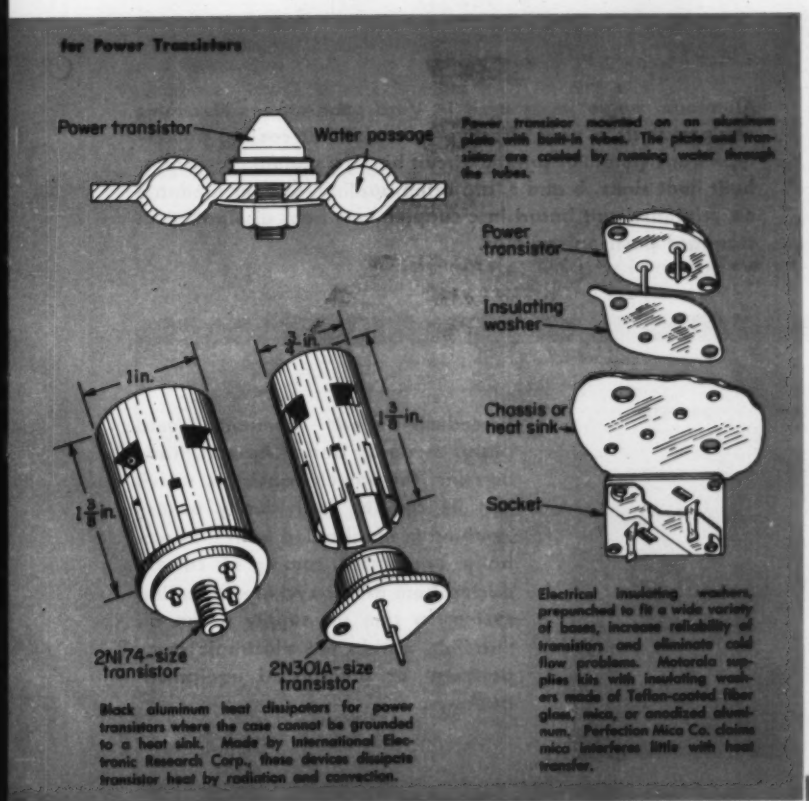
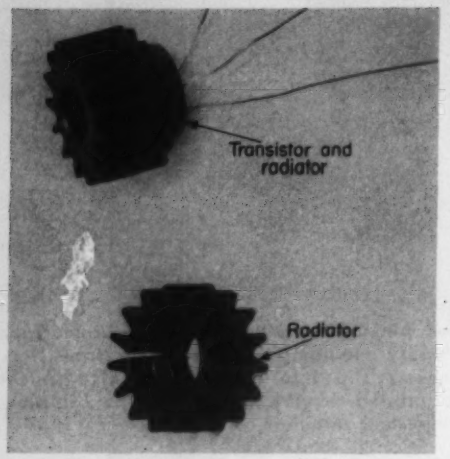
Systems Development Dept.
Vitro Laboratories
Silver Spring, Maryland

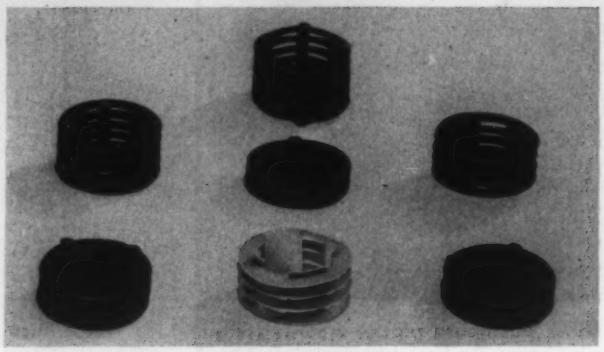

for Power Transistors
Power transistor
Water passage
Power transistor mounted on an aluminum plate with built-in tubes. The plate and transistor are cooled by running water through the tubes.
Power transistor
Insulating washer
Chassis or heat sink
Socket
1 in.
¾ in.
1⅜ in.
1⅜ in.
2N174-size transistor
2N301A-size transistor
Black aluminum heat dissipators for power transistors where the case cannot be grounded to a heat sink. Made by International Electronic Research Corp., these devices dissipate transistor heat by radiation and convection.
Electrical insulating washers, prepunched to fit a wide variety of bases, increase reliability of transistors and eliminate cold flow problems. Motorola supplies kits with insulating washers made of Teflon-coated fiber glass, mica, or anodized aluminum. Perfection Mica Co. claims mica interferes little with heat transfer.

WAYS of mounting transistors on either printed-circuit boards or metal chassis are as many and varied as the shapes and sizes of transistors themselves. Selection of a particular transistor-mounting method is controlled primarily by satisfying two important design requirements:

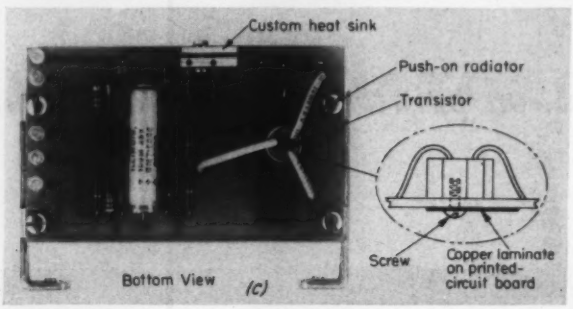
1. Holding the transistor securely without straining its electrical leads.
2. Providing a good heat-dissipation path from the transistor to the heat sink.

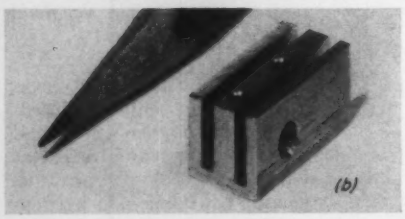
Often, simple mounting brackets or chassis design modifications meet these requirements quite satisfactorily. However, there are also several types of mounting clips, sockets, and holders available which are specially designed for retaining transistors.



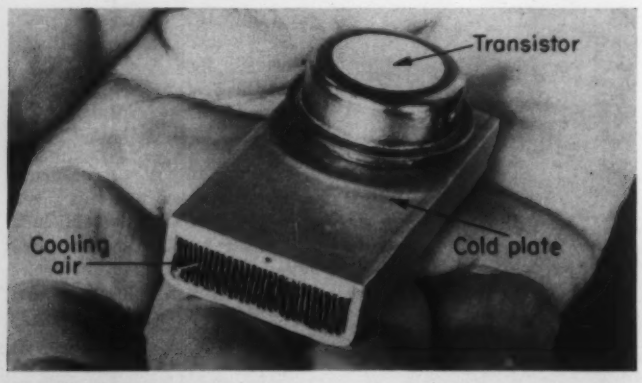


Two types of push-on radiators which provide an efficient method of radiation cooling of transistors. These radiators are manufactured by the Birtcher Corp.





Aluminum angle, *a*, is used in Vitro Laboratories electronic equipment as a very effective heat sink for cooling power-type transistors. For printed-circuit boards, aluminum custom-built heat sinks, *b* and *c*, are often applied. Copper laminate on printed-circuit board in c supplements heat dissipation of standard push-on radiator.



Forced-air-cooled aluminum cold plates made by United Aircraft Products Inc. for power transistors which can be applied individually or assembled in manifolded banks. In airborne equipment, cooling air can be ducted from an air-cycle refrigeration system, a ram air supply or an air manifold within the electronic compartment or pressurized equipment package.

MOMENT GRIDS

Direct measurements on grid overlays simplify evaluation of moments of irregular sections or surfaces. In this article, a basic grid technique, adaptable to any size section, is supplemented by tables of grid ordinates. The tables are graduated to provide a selection of grid range and density.

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MOMENT grids are a convenient means for evaluating moments of irregular areas. A typical grid consists simply of a set of parallel lines spaced in accordance with a known algebraic law. In Fig. 1, solid horizontal lines are grid lines, and horizontal dash lines are boundaries of grid elements. The grid axis is superposed on the axis of reference about which moments are taken. Summation of measured lengths l yields an approximate value of moment M. That is,

$$M_{p,x} = a \sum_{n=1}^{n(max)} l_n \qquad (1)$$

Since the grid axis is an element boundary line, not a grid line, its length l is not included in Equation 1.

The grid can be made on transparent paper and superposed on a drawing of the section considered. Another practice is to indicate grid line positions by short horizontal marks directly on the section drawing. Then lengths l can be measured by using a

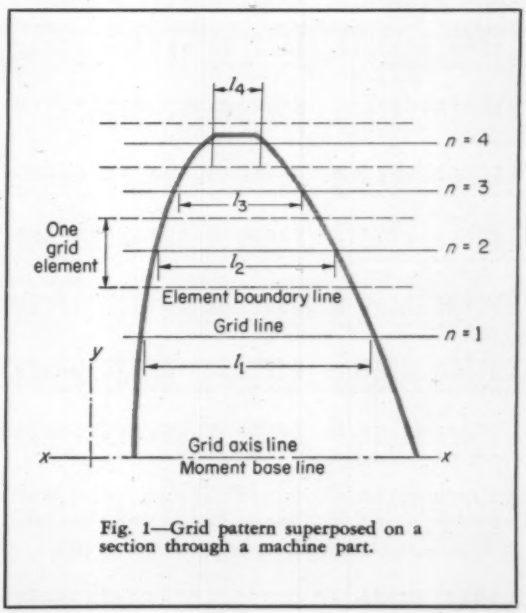

Fig. 1—Grid pattern superposed on a section through a machine part.

Nomenclature

A = Area
a = Scale factor
C = Correction factor for cut-off length of an element adjacent to axis
$I_{m,x}$ = Mass moment of inertia of a solid of revolution about axis xx
K = Arbitrary magnification factor
k = Arbitrary positive integral exponent
l_n = Length of grid line n between intersections with section contour
$M_{p,x}$ = Moment, of order p, about axis xx = $\int y^p dA$
m = Serial number of grid in table
n = Serial number of grid line, counting outward from grid axis
p = Index or order of moment
y = Moment arm about axis xx
y_n = Distance of nth grid line from axis xx
ρ = Mass per unit volume

Table 1—Distances of Grid Lines from Grid Axis

First-Moment Grids

m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
a	0.6323	0.6466	0.6512	0.6644	0.6811	0.1021	0.1285	0.1618	0.204	0.256	0.323	0.406	0.512	0.644	0.811	1.021	1.285	1.618	2.04	2.56
n																				
1	0.180	0.202	0.226	0.254	0.285	0.320	0.358	0.402	0.451	0.506	0.568	0.637	0.715	0.803	0.900	1.010	1.134	1.272	1.427	1.601
2	0.311	0.349	0.392	0.440	0.493	0.553	0.621	0.697	0.782	0.877	0.984	1.104	1.239	1.390	1.560	1.750	1.964	2.203	2.472	2.774
3	0.402	0.451	0.506	0.567	0.637	0.714	0.802	0.899	1.009	1.132	1.270	1.425	1.599	1.795	2.014	2.259	2.535	2.844	3.191	3.581
4	0.475	0.533	0.598	0.671	0.753	0.845	0.948	1.064	1.194	1.340	1.503	1.687	1.892	2.123	2.382	2.673	2.999	3.365	3.776	4.237
5	0.539	0.605	0.679	0.761	0.854	0.958	1.075	1.207	1.354	1.519	1.704	1.912	2.146	2.408	2.701	3.031	3.401	3.816	4.281	4.804
6	0.596	0.669	0.750	0.842	0.944	1.060	1.189	1.334	1.497	1.679	1.884	2.114	2.372	2.662	2.987	3.351	3.760	4.219	4.733	5.311
7	0.648	0.727	0.816	0.915	1.027	1.152	1.293	1.450	1.627	1.826	2.049	2.298	2.579	2.894	3.247	3.643	4.087	4.586	5.146	5.774
8	0.696	0.781	0.876	0.983	1.103	1.237	1.388	1.558	1.748	1.961	2.200	2.469	2.770	3.106	3.487	3.913	4.390	4.926	5.527	6.202
9	0.741	0.831	0.933	1.046	1.174	1.317	1.478	1.658	1.861	2.088	2.343	2.628	2.949	3.306	3.713	4.166	4.674	5.244	5.884	6.602
10	0.783	0.879	0.986	1.106	1.241	1.393	1.563	1.753	1.967	2.207	2.477	2.779	3.118	3.498	3.925	4.404	4.941	5.544	6.221	6.980
11	0.823	0.924	1.037	1.163	1.305	1.464	1.643	1.843	2.068	2.320	2.604	2.921	3.278	3.678	4.126	4.630	5.195	5.829	6.540	7.338
12	0.862	0.967	1.085	1.217	1.366	1.532	1.719	1.929	2.164	2.428	2.725	3.057	3.430	3.849	4.318	4.845	5.437	6.100	6.844	7.680
13	0.898	1.008	1.131	1.269	1.424	1.598	1.792	2.011	2.257	2.532	2.841	3.187	3.576	4.013	4.502	5.052	5.668	6.360	7.136	8.006
14	0.934	1.047	1.175	1.319	1.480	1.660	1.863	2.090	2.345	2.631	2.952	3.312	3.717	4.170	4.679	5.250	5.890	6.609	7.416	8.320
15	0.968	1.086	1.218	1.367	1.533	1.721	1.930	2.166	2.430	2.727	3.060	3.433	3.852	4.322	4.849	5.441	6.105	6.850	7.686	8.623
16	1.000	1.122	1.259	1.413	1.585	1.779	1.996	2.240	2.513	2.819	3.163	3.549	3.982	4.468	5.014	5.625	6.312	7.082	7.946	8.916
17	1.032	1.158	1.299	1.458	1.636	1.835	2.059	2.311	2.593	2.909	3.264	3.662	4.109	4.610	5.173	5.804	6.512	7.307	8.198	9.199
18	1.063	1.193	1.338	1.501	1.685	1.890	2.121	2.380	2.670	2.996	3.361	3.771	4.232	4.748	5.327	5.977	6.707	7.525	8.443	9.474
19	1.093	1.226	1.376	1.544	1.732	1.943	2.181	2.447	2.745	3.080	3.456	3.878	4.351	4.882	5.477	6.146	6.896	7.737	8.681	9.740
20	1.122	1.259	1.413	1.585	1.778	1.995	2.239	2.512	2.818	3.162	3.548	3.981	4.467	5.012	5.623	6.310	7.080	7.943	8.912	10.000

Second-Moment Grids

m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
a	0.0241	0.0341	0.0482	0.0681	0.0961	0.1358	0.1918	0.271	0.383	0.541	0.764	1.079	1.524	2.15	3.04	4.29	6.07	8.57	12.10	17.09
n																				
1	0.331	0.371	0.417	0.467	0.524	0.588	0.660	0.741	0.831	0.932	1.046	1.174	1.317	1.478	1.658	1.861	2.088	2.342	2.628	2.949
2	0.477	0.535	0.601	0.674	0.756	0.849	0.952	1.068	1.199	1.345	1.509	1.693	1.900	2.132	2.392	2.683	3.011	3.378	3.790	4.253
3	0.586	0.635	0.712	0.799	0.897	1.006	1.129	1.267	1.421	1.595	1.789	2.007	2.252	2.527	2.836	3.182	3.570	4.005	4.494	5.042
4	0.633	0.710	0.797	0.894	1.003	1.126	1.263	1.417	1.590	1.784	2.001	2.246	2.520	2.827	3.172	3.559	3.993	4.481	5.027	5.641
5	0.658	0.772	0.866	0.972	1.091	1.224	1.373	1.541	1.729	1.940	2.176	2.442	2.740	3.074	3.449	3.870	4.342	4.872	5.467	6.134
6	0.736	0.826	0.926	1.039	1.166	1.309	1.468	1.647	1.848	2.074	2.327	2.611	2.929	3.287	3.688	4.138	4.643	5.209	5.845	6.558
7	0.778	0.873	0.979	1.099	1.233	1.383	1.552	1.742	1.954	2.193	2.460	2.760	3.097	3.475	3.899	4.375	4.909	5.508	6.180	6.934
8	0.816	0.916	1.027	1.153	1.293	1.451	1.628	1.827	2.050	2.300	2.580	2.895	3.248	3.645	4.090	4.589	5.148	5.777	6.482	7.272
9	0.851	0.955	1.071	1.202	1.348	1.513	1.697	1.905	2.137	2.398	2.690	3.019	3.387	3.800	4.264	4.784	5.368	6.023	6.758	7.582
10	0.883	0.991	1.111	1.247	1.399	1.570	1.762	1.976	2.218	2.488	2.792	3.133	3.515	3.944	4.425	4.965	5.571	6.250	7.013	7.869
11	0.913	1.024	1.149	1.289	1.447	1.623	1.821	2.044	2.293	2.573	2.887	3.239	3.634	4.077	4.575	5.133	5.760	6.462	7.251	8.136
12	0.941	1.056	1.185	1.329	1.491	1.673	1.877	2.106	2.364	2.652	2.976	3.339	3.744	4.200	4.711	5.285	5.931	6.654	7.464	8.372
13	0.967	1.086	1.218	1.367	1.533	1.720	1.930	2.166	2.430	2.727	3.059	3.430	3.848	4.317	4.842	5.431	6.091	6.831	7.664	8.597
14	0.993	1.114	1.250	1.402	1.573	1.765	1.980	2.222	2.493	2.798	3.139	3.522	3.952	4.434	4.975	5.582	6.263	7.027	7.884	8.846
15	1.017	1.141	1.280	1.436	1.611	1.808	2.028	2.276	2.553	2.865	3.214	3.607	4.047	4.541	5.095	5.716	6.414	7.196	8.074	9.060
16	1.039	1.166	1.306	1.468	1.647	1.848	2.074	2.327	2.611	2.929	3.287	3.688	4.138	4.643	5.209	5.845	6.558	7.358	8.256	9.263
17	1.061	1.191	1.336	1.499	1.682	1.887	2.117	2.376	2.666	2.991	3.356	3.766	4.225	4.740	5.319	5.968	6.696	7.513	8.430	9.458
18	1.082	1.214	1.362	1.529	1.715	1.925	2.159	2.423	2.719	3.050	3.422	3.840	4.309	4.834	5.424	6.086	6.829	7.662	8.597	9.646
19	1.102	1.237	1.388	1.557	1.747	1.961	2.200	2.468	2.769	3.107	3.486	3.912	4.389	4.925	5.526	6.200	6.956	7.805	8.758	9.826
20	1.122	1.259	1.413	1.585	1.778	1.995	2.239	2.512	2.818	3.162	3.548	3.981	4.467	5.012	5.623	6.310	7.080	7.943	8.912	10.000

Third-Moment Grids

m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
a	0.0203	0.0322	0.0510	0.0809	0.1282	0.203	0.322	0.510	0.809	1.282	2.03	3.22	5.10	8.09	12.82	20.3	32.2	51.0	80.9	128.2
n																				
1	0.449	0.504	0.565	0.634	0.712	0.798	0.896	1.005	1.128	1.265	1.420	1.593	1.787	2.006	2.250	2.525	2.833	3.179	3.566	4.002
2	0.591	0.663	0.744	0.835	0.937	1.051	1.179	1.323	1.484	1.665	1.869	2.097	2.352	2.640	2.962	3.323	3.728	4.183	4.694	5.266
3	0.671	0.753	0.845	0.948	1.064	1.194	1.340	1.503	1.686	1.892	2.123	2.382	2.673	2.999	3.365	3.776	4.236	4.753	5.333	5.984
4	0.730	0.819	0.919	1.032	1.157	1.299	1.457	1.635	1.834	2.058	2.309	2.591	2.907	3.262	3.660	4.107	4.608	5.170	5.801	6.509
5	0.778	0.873	0.979	1.098	1.233	1.383	1.552	1.741	1.953	2.192	2.459	2.758	3.096	3.474	3.898	4.373	4.907	5.506	6.177	6.931
6	0.818	0.917	1.029	1.155	1.296	1.454	1.631	1.831	2.054	2.305	2.586	2.901	3.255	3.652	4.098	4.598	5.159	5.789	6.495	7.288
7	0.853	0.957	1.073	1.204	1.351	1.516	1.701	1.909	2.142	2.403	2.696	3.025	3.394	3.808	4.273	4.794	5.379	6.036	6.772	7.598
8	0.884	0.991	1.112	1.248	1.400	1.571	1.763	1.978	2.220	2.490	2.794	3.135	3.518	3.947	4.428	4.969	5.575	6.255	7.019	7.875
9	0.912	1.023	1.148	1.288	1.445	1.621	1.819	2.041	2.290	2.570	2.883	3.235	3.630	4.072	4.569	5.127	5.752	6.454	7.242	8.126
10	0.937	1.052	1.180	1.324	1.486	1.667	1.870	2.099	2.355	2.642	2.964	3.326	3.732	4.187	4.698	5.271	5.915	6.636	7.446	8.354
11	0.961	1.078	1.210	1.358	1.523	1.709	1.918	2.152	2.414	2.709	3.039	3.410	3.826	4.293	4.817	5.405	6.064	6.804	7.635	8.566
12	0.983	1.103	1.238	1.389	1.558	1.749	1.962	2.201	2.470	2.771	3.109	3.489	3.914	4.392	4.928	5.529	6.204	6.961	7.810	8.763
13	1.004	1.126	1.264	1.418	1.591	1.785	2.003	2.248	2.522	2.830	3.175	3.562	3.997	4.485	5.032	5.646	6.335	7.108	7.975	8.948
14	1.023	1.148	1.288	1.446	1.622	1.820	2.042	2.291	2.571	2.885	3.237	3.631	4.075	4.572	5.130	5.755	6.455	7.246	8.130	9.122
15	1.042	1.169	1.312	1.472	1.651	1.853	2.079	2.333	2.617	2.937	3.295	3.697	4.148	4.654	5.222	5.859	6.574	7.376	8.276	9.286
16	1.059	1.189	1.334	1.497	1.679	1.884	2.114	2.372	2.661	2.986	3.350	3.759	4.218	4.732	5.310	5.958	6.685	7.500	8.416	9.442
17	1.076	1.207	1.355	1.520	1.706	1.914	2.147	2.409	2.703	3.033	3.403	3.818	4.283	4.807	5.393	6.051	6.790	7.618	8.548	9.591
18	1.092	1.225	1.375	1.543	1.731	1.942	2.179	2.445	2.743	3.078	3.454	3.875	4.348	4.878	5.473	6.141	6.891	7.731	8.675	9.738
19	1.107	1.242	1.394	1.564	1.755	1.969	2.209	2.479	2.782	3.122	3.502	3.929	4.408	4.946	5.550	6.227	6.987	7.840	8.796	9.868
20	1.122	1.259	1.413	1.585	1.778	1.995	2.239	2.512	2.818	3.162	3.548	3.981	4.467	5.012	5.623	6.310	7.080	7.943	8.912	10.000

parallel rule and scale.

Table 1 lists the ordinates of grid lines for convenient sizes of first, second, and third moment grids. Each numbered column pertains to one grid. In each table, the first grid depth is $10^{0.05} = 1.122$ units. The second is $10^{0.10} = 1.259$. Depth of the last grid is 10 units.

To work with larger sections, multiply the listed grid ordinates by 10^k and the listed scale factors by $10^{kp+k} = (10^k)^{p+1}$. For smaller sections, divide correspondingly.

If a drawing is made to the scale of 1 unit = K units in the actual figure, determine the moment of the drawn figure, then multiply that moment by K^{p+2} to obtain the moment of the actual section. The exponent changes from $p + 1$ to $p + 2$ because: In the first case, magnification applies only in the direction transverse to the axis. In the second case, it applies in both directions.

The basic assumption of the grid method is that each element of a given figure has the same moment about the reference axis as a rectangular element with the same l_n between the same element boundaries. Therefore, equations can be derived to relate grid-line ordinates and scale factor. Consider a rectangle of unit width extending over an integral number of elements. Equate the expression of a moment as found by the grid method, to the expression obtained by direct integration. Thus,

$$a\left(n - \frac{1}{2}\right) = \left(\frac{1}{p+1}\right) y_n^{p+1} \qquad (2)$$

$$y_n^{p+1} = a\left(p+1\right)\left(n - \frac{1}{2}\right) \qquad (3)$$

$$y_n = \left[a\left(p+1\right)\left(n - \frac{1}{2}\right)\right]^{1/(p+1)} \qquad (4)$$

Equation 4 has been used to calculate the mean distances y_n in Table 1. From Equation 2, the scale factor is

$$a = \frac{y_n^{p+1}}{(p+1)(n - \frac{1}{2})} \qquad (5)$$

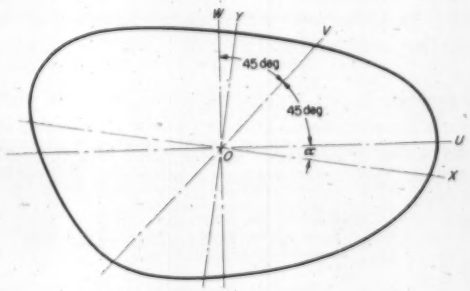

Fig. 2—Directions of principal axes of inertia.

Corrections: Often, an area farthest from the grid axis fails to reach an element boundary. This case makes separate treatment necessary. Thus, the l_4 value in Fig. 1 was chosen—by visual estimation—to make the area of the grid rectangle equal to that enclosed by the section contour and grid boundary. Similar estimation applies if there is abrupt change in the width of a section at some distance below the extreme fiber region. This procedure is sufficiently accurate if at least several grid lines with lesser ordinates are used.

A different kind of correction is required when, for example, a first element has zero width at the axis. In one such form, the width of the first element is proportional to y. In another, width is proportional to $y^{1/2}$.

The first type often occurs as part of a trapezoidal element in which the shorter parallel side lies on the axis. A correction is necessary, Table 2, only for the triangular portion of the element having its horizontal dimension proportional to y. The second type is rare. Its correction factor C applies when a first element has the form of a circular segment, which is approximated by a parabola, Table 2.

In each case, the l_1 value should be reduced through multiplication by the proper correction factor before substitution in Equation 1. The fact that all the listed values of C are close to unity indicates accuracy attainable with the grid method. Even if the first element were a semicircular segment, 0.8 per cent would be the greatest error committed in applying the correction factor.

Axes Unknown: To find the second moment of a figure about its neutral axis, when the location of that axis is not known, determine the first moment about an axis through one of the extreme fiber locations. From this result, find the distance to the neutral axis by dividing the first moment by the area. The second moment can be obtained by using a two-sided second-moment grid with its axis on the neutral axis. This procedure is more accurate than

Table 2—Correction Factors, C

	First Moment $p = 1$	Second Moment $p = 2$	Third Moment $p = 3$
Triangle	0.943	0.945	0.951
Parabola	0.951	0.962	0.969

transferring the second moment from the orginal axis.

In an alternative procedure, place a two-sided first-moment grid with its axis on the location of the neutral axis, approximated by eye. Then the net first moment, with respect to the assumed axis, is calculated as the difference of the moments to the two sides of that axis. The remainder of the procedure is conventional practice.

If a section has no axis of symmetry, the principal axes *OX* and *OY*, and the principal moments of inertia can be found from the moments of inertia about three arbitrary axes *OU*, *OV*, and *OW* taken at 45-degree intervals through the center of gravity, Fig. 2. The angle α, which determines the directions of the principal axes, is calculated from

$$\tan 2\alpha = \frac{2M_{2,v} - M_{2,u} - M_{2,w}}{M_{2,w} - M_{2,u}} \quad (6)$$

Angle α is measured from *OU* in the direction away from *OV*. Then the principal moments of inertia are found from

$$M_{2,x} = \frac{1}{2}(M_{2,u} + M_{2,w}) + \frac{1}{2}(M_{2,u} - M_{2,w}) \sec 2\alpha \quad (7)$$

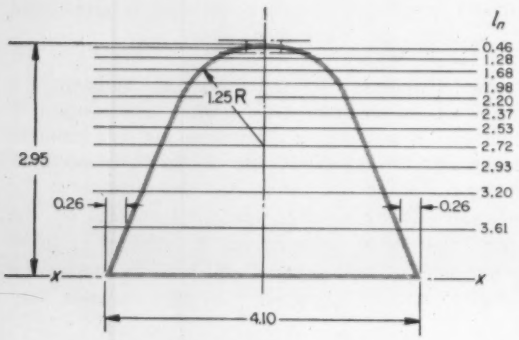

Fig. 3—First-moment example.

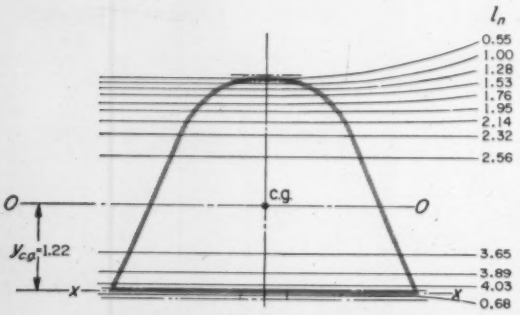

Fig. 4—Second-moment example.

$$M_{2,y} = \frac{1}{2}(M_{2,u} + M_{2,w}) - \frac{1}{2}(M_{2,u} - M_{2,w}) \sec 2\alpha \quad (8)$$

The third moment is useful in calculating the mass moment of inertia of a solid of revolution with respect to its axis of revolution. If the third moment of a section on one side of the axis is $M_{3,x}$, by direct integration,

$$k_{m,x} = \int 2\pi\rho y^3 dA = 2\pi\rho M_{3,x} \quad (9)$$

Example 1: Find first moment of the shape in in Fig. 3.

Use first-moment grid 12, Table 1. The value $l_n = 0.46$ is the estimated length of an equivalent rectangle. Calculation of the value $l_n = 3.61$ employs the correction factor $C = 0.943$ from Table 2, thus

$$l_1 = 4.10 - 2(0.26)(0.943) = 3.61$$

From Equation 1, the first moment is

$$M_{1,x} = a\sum_{n=1}^{n=11}(l_n) = 0.406(24.96) = 10.13 \text{ in.}^3$$

The ordinate of the center of gravity is

$$y_{c.g.} = \frac{M_{1,x}}{A(\text{by planimeter})} = \frac{10.13}{8.31} = 1.22$$

Example 2: Find second moment of the same shape, Fig. 4.

Use second-moment grid 7, Table 1. The values $l_n = 0.55$ and 0.68 are estimated lengths of equivalent rectangles. From Equation 1, the second moment is

$$M_{2,o} = a\sum_{n=1}^{n(max)}(l_n)_{\text{lower+upper}} =$$

$$(0.1918)(27.34) = 5.24 \text{ in.}^4$$

The first grid line lengths above and below the centroid in the calculation for second moment might have been corrected by the procedure for first moment. In this case, correction is unnecessary because they are equal and opposite.

Example 3: To obtain the third moment about *xx*, use third-moment grid 11, Table 1, and proceed as for a first moment (Example 1). With corrections included,

$$M_{3,x} = a\sum_{n=1}^{n(max)}(l_n) = (2.03)(17.53) = 35.6 \text{ in.}^5$$

Mass moment of inertia of this section would be

$$I_{m,x} = 2\pi\rho M_{3,x} = (6.28)(0.283)(35.6) = 63.2 \text{ lb-in.}^2$$

if it were made of steel with $\rho = 0.283$ lb per cu in.

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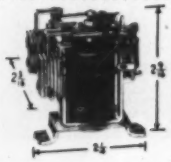
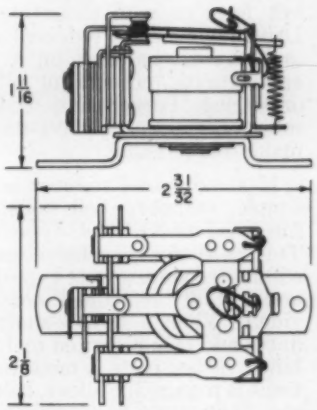
SPST-NC	SPDT	DPDT	3PDT
SPST-NO-DB	DPST-NO	3PST-NO	

For more information about this medium duty, compact relay, call or write today—or get in touch with the P&B sales engineer nearest you. See our complete catalog in Sweet's Product Design File.



LM SERIES: Plate circuit relays similar to the MR. All sp and dp contact arrangements shown above are available. Coils are wound to specified resistances up to 58,000 ohms max. Sensitivity ranges from 15 mw min. (single pole) to 70 mw min. (double pole).

MR SERIES



GENERAL SPECIFICATIONS:

Breakdown: 1500 volts, 60 cycle rms between all elements.

Temperature Range:
DC —55°C. to +85°C.
AC —55°C. to +75°C.

Pull-in: Approx. 75% of nominal dc voltage; 78% of nominal ac voltage.

Weight: 4 ozs.

Dimensions: 2 31/32" long x 2 1/16" wide x 2" high.

Mounting: Two 9/32" dia. holes. Can be adapted for printed circuits.

CONTACTS:

Arrangements: Up to 3pdt.

Material: 7/32" dia. silver. (Others available).

Load: 8 amps @ 115 volts, 60 cycle, resistive.

COIL:

Max. Resistance: 34,500 ohms.

Power: 1.5 watts dc; 3.25 volt-amps ac. Will withstand up to 6 watts at 25°C.

Voltages: Up to 110 volts dc; up to 440 volts 60 cycle ac.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

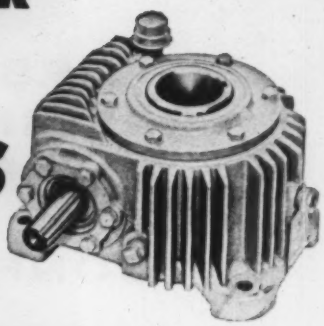
POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

IN CANADA: POTTER & BRUMFIELD CANADA, LTD., GUELPH, ONTARIO

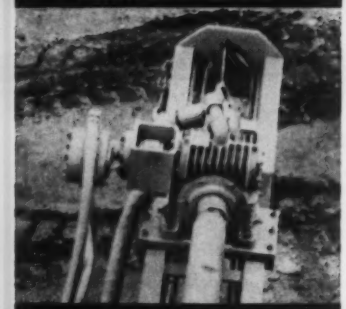
Circle 472 on Page 19

CONE-DRIVE WORM GEAR HOLLOW SHAFT SPEED REDUCERS

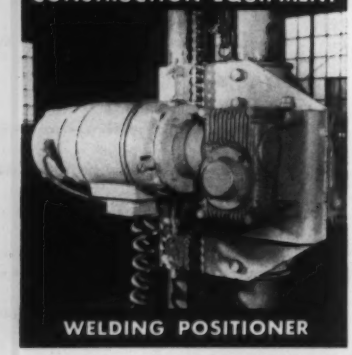


provide greater flexibility in the design of your equipment

MIXING MACHINE



CONSTRUCTION EQUIPMENT



WELDING POSITIONER

Standard Cone-Drive hollow shaft speed reducers are available in four basic sizes (2, 2½, 3 and 3½ inch center distance units) to accommodate loads from fractional to 13 horsepower. They are built around the double-enveloping worm gear design and carry the same high ratings as standard Cone-Drive speed reducers.

You, as a designer, will be particularly interested in the versatility of application and space savings made possible by the right angle design between input and output shafts.

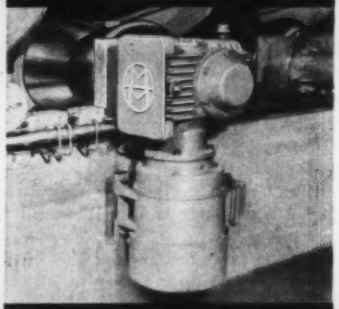
The reducer is mounted directly on the driven shaft and requires only a simple bracket or torque arm to prevent it from rotating about the driven shaft.

Construction is rugged enough to permit floor or wall mounting of Cone-Drive hollow shaft reducers and "hanging" the driven shaft on it (in certain applications), eliminating pillow blocks or bearings. Larger-than-necessary taper roller bearings and heavy-duty castings make this possible.

If a motorized reducer is desired, a simple, standard bell housing can be furnished for NEMA C-type face motors. The need for expensive couplings is eliminated since a tang-type drive sleeve and suitably machined worms are provided. When a hollow-shaft speed reducer and face-mounted motor are combined, no bed plate or mounting arrangement is required. Pulleys, belts, sheaves, etc., that might be troublesome or difficult to install are also eliminated.

Ask for Bulletin CD-218.

TROLLEY HOIST



MILL ROLL DRIVE

LAUNDRY MACHINE

CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

7171 E. McNichols Road • Detroit 12, Michigan • Telephone: TWinbrook 1-3111

DOUBLE-ENVELOPING WORM GEARSETS

DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS

Special charts aid in
Designing Rubber Extrusions

G. WILLIAM BECK
Ass't. Chief Engineer
Inland Mfg. Div.
Dayton, Ohio

Handy extrudability charts show whether or not a uniform or nonuniform section can be extruded and, if so, what minimum thickness and tolerances are practical. They also indicate suitable hardness and tensile-strength values of materials for extruding.

FACTORS governing the successful extrusion of a product can be integrated into the term "extrudability"—the degree of perfection to which the product can be extruded. These factors are:

1. Variation in cross-section thickness of a part and complexity of shape.
2. Length of uncured piece to be handled.
3. Physical properties and kind of compound used for the product.

Section and Length: A section having uniform thickness can be extruded more easily in soft material than a section with different thicknesses. Also, irregular sections may require support during cure.

Thin sections cannot be handled in straight lengths over 60 in. and still be held to close tolerances. Uniform tolerances can be held over the entire length of the extrusion if the section design is such that the product can be coiled during cure.

Compounds: In general, closer tolerances can be held and thinner sections fabricated with hard compounds than with soft compounds. Also, extrusions from high tensile-strength compounds require greater tolerances and thicker sections than those from low-strength compounds.

Crude natural rubber, GR-S, neoprene, Buna-N (oil-resistant acrylonitrile), butyl, and silicone materials can be compounded to extrude a variety of satisfactory sections. Because of the physical characteristics of natural rubber and various synthetic polymers, it is more practical to use natural rubber or neoprene than other synthetics to obtain tensile strengths above 2000 psi. The maximum tensile strength obtainable with silicone is in the range of 700 to 1000 psi.

Chart Use: The extrudability charts, Fig. 1*a* and *b*, can be used

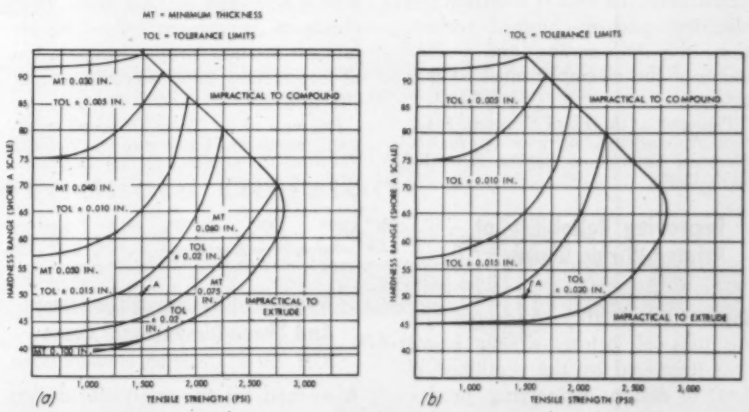


Fig. 1—Relationship of hardness and tensile strength of rubber compounds to minimum section thickness and tolerances for extrusions. Chart *a* is applicable to parts having thin, uniform cross sections. Chart *b* is applicable to parts having nonuniform sections. Note that absolute minimum hardness is greater for materials used in nonuniform sections than for those used in uniform sections.

in several ways. If one of the factors collated by the charts is given for a specific extrusion, the charts reveal what limitations that factor places on the nature of the extrusion. If more than one factor is given, the charts show how the relationship of the factors will affect the nature of the extrusion.

Fig. 1*a* relates hardness, tensile strength, and tolerance limits to the minimum practical uniform thickness that can be extruded satisfactorily. For example, if a material must have a hardness of 50 (Shore durometer, A scale) and a 1500-psi tensile strength (point A), the product can be extruded with a minimum thickness of 0.060 ±0.020 in. If tensile strength and hardness co-ordinates fall outside the longest curve, the extrusion is impractical.

Also, if the designer knows that the product requires a certain uniform thickness, the chart will indicate hardness and tensile-strength values for a material suitable for extruding.

Fig. 1*b* shows the relationship of hardness, tensile strength, and tolerances for extrusions with nonuniform cross sections that have a great variation in section thickness. Here, two significant facts are of interest. First, the chart shows that the absolute minimum hardness of compounds for extruding nonuniform thin sections is higher (45 Shore A) than that for extrusions of uniform thickness (37 Shore A, Fig. 1*a*). The minimum hardness of 45 Shore A would be covered by a specification of 50 ±5 and means that 50 is the minimum hardness that should be specified. This condition exists because of the higher swell characteristics of softer materials and the difficulty encountered in building an extruding die to produce thin sections immediately adjacent to thick sections.

The second significant fact of interest is that the closer tolerances indicated for higher-hardness and relatively lower-tensile materials are in line with the thinner extrusions permissible in these same physical ranges, Fig. 1*a*. This relationship exists because of the lower swell characteristics of materials in these hardness and tensile ranges.

Referring to Fig. 1*b*, if a set of physical requirements for the material is given, a practical extruding tolerance can be determined. If the product application demands close tolerances, the chart can be used to determine required hardness and tensile strength of a suitable material.

It should be emphasized that these extrudability charts are intended only as guides for the designer. It is probable that many production applications of extrusions violate the limits shown on the charts. But, more than likely, a higher cost is reflected in these parts because of higher scrap allowance, higher handling costs, or higher material costs resulting from the use of specialized compounds.

General Motors Engineering Journal, *Vol.* 6, *No.* 1, *Jan.-Feb.-March*, 1959; *Pp.* 18-20.

electrical

Reliable Electrical Connections

W. F. Bonwitt and H. P. Dupre, Burndy Corp.

An evaluation of various types of compression connections which are relatively new to the electronics industry. Principles of these connections and practical applications are covered. Effects of mechanical crimping on electrical resistance of the connections are discussed. Curves show the relationship between relative conductivity and deformation. To obtain a satisfactory electrical and mechanical connection, the deformation and pullout value of the assembly must be considered.

Presented at the Third Electronic Industries Association Conference on Reliable Electrical Connections, Dallas, December, 1958; 12 pp.

Improving Reliability of Printed-Wiring Boards

W. G. Jezowski, General Electric Co.

How the reliability of through-connections of printed-wiring boards was improved by the combined efforts of design engineering, production, and quality control groups. The role of each group in contributing to an improved design and design standards is covered.

Presented at the Third Electronic Industries Association Conference on Reliable Electrical Connections, Dallas, December, 1958; 6 pp.

Reliability of Multisplicing Wiring Systems

D. A. Byers and M. D. Bergan, The Thomas and Betts Co.

Advantages of the crimp-type, self-insulated splice connections in electrical circuit work. Techniques are contrasted to methods of joining with screws and binding posts. Emphasis on permanent-spliced installations include proper preparation of conductors and selecting proper size splice.

Presented at the Third Electronic Industries Association Conference on Reliable Electrical Connections, Dallas, December, 1958; 19 pp.

mechanical

Analytical Design of Disc Cams And Three-Dimensional Cams

F. H. Raven, University of Notre Dame

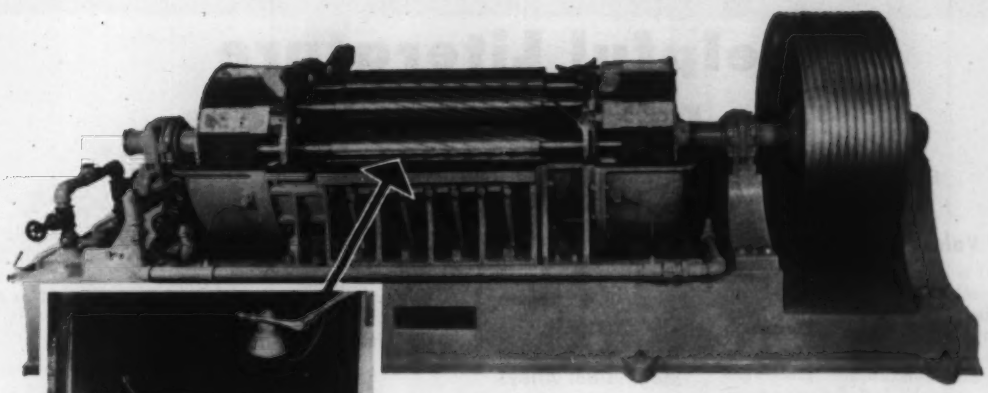
A method for the analytical design of cams based upon independent-position equations. From these equations, one can obtain general expressions for cam parameters such as contour, pressure angles, and radii of curvature. This procedure is applicable for cam systems with any type of follower motion. The mathematical directness of this method makes it possible to investigate thoroughly even the most complicated three-dimensional cam situations. How design charts and procedures may be developed to facilitate solutions of particular cam design problems is demonstrated.

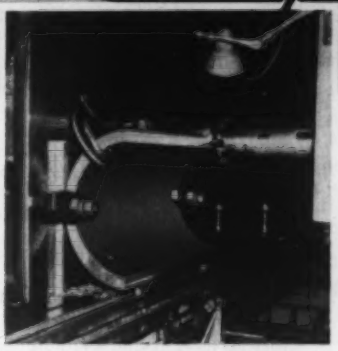
ASME paper 58-A-17, *ASME Annual Meeting, New York, December*, 1958; 7 *pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; paper 40 cents, to members, 80 cents to nonmembers.

The Electronic Industries Assoc., 11 West 42nd St., New York, N. Y.





How the pulp industry "beats" its reject losses with...

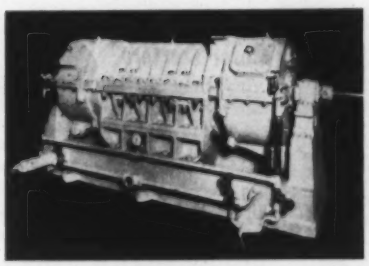
ACIPCO

stainless steel liners

Size Range Lengths up to 410" have been produced to meet modern machinery requirements. OD's from 2.25" to 50"; wall thicknesses from .25" to 4"

Analyses All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

Finished As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.



Reject recovery with Anton J. Haug refiners is saving paper mills more than $7 million per year in wood alone! ACIPCO *furnishes tough, durable, stainless steel liners which go inside the main casings of the machines.*

In Canada, Europe, South America, Japan—as well as in this nation's largest paper mills—refiners manufactured by Anton J. Haug are saving more than 700 tons of good groundwood, sulphite and kraft rejects *each day*. This refined stock is marketed at the same price as virgin pulp—and the annual savings in wood alone is more than $7 million!

ACIPCO plays an important part in reject recovery by furnishing the stainless steel lining which goes inside the main casing of the Haug refiner. The lining, statically cast to Haug's exacting specifications, fits inside a stationary cylindrical shell.

Stock, entering at one end, travels through the machine in a helical path and is *repeatedly subjected to the pressure of high speed rolls which crush it against the liners.*

In special shapes such as this, as well as centrifugally spun steel tubes, ACIPCO castings stand up . . . under the longest, toughest assignments. If *your* application is a special one, it will be worthwhile for you to investigate ACIPCO's facilities for casting, heat treating, machining, fabricating and testing.

Stainless steel, carbon steel, alloy iron or special analyses—versatile ACIPCO tubes are made to solve your specific tubular metal problem. Call ACIPCO today for complete information—or for expert technical assistance.

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Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Solenoid Valves

Over 200 types and sizes of bronze and stainless steel solenoid valves for temperatures from −300 to 500° F and pressures from 0 to 10,000 psi are described in Catalog No. 444. Types for air, steam, corrosive and noncorrosive gases, and liquids are covered. Included are specifications, performance data, and circuit diagrams. 36 pages. Atkomatic Valve Co., 545 W. Abbott St., Indianapolis 25, Ind. J

Circle 601 on Page 19

Blowers & Pumps

Heavy duty antifriction bearings, wide face timing gears, capacities to 1600 cfm, pressures to 10 lb, and vacuums to 20 in. Hg are features of California Series of positive pressure blowers, gas pumps, and vacuum pumps. Specifications are given in illustrated Bulletin S-59G. Sutorbilt Corp., 2966 E. Victoria St., Compton, Calif. L

Circle 602 on Page 19

Bearing Take-Up Units

Catalog BU-101-B explains advantages of a new line of take-up units which combine antifriction bearings with unbreakable malleable housing, welded steel frames, and cadmium plated adjusting screws. Stock sizes are listed. Complete specifications are given also for pillow blocks, flange blocks, and ball bearings. 16 pages. Browning Mfg. Co., Maysville, Ky. G

Circle 603 on Page 19

Industrial & Motor Controls

Magnetic contactors, starters, and reversing contactors are described in brochure along with starter-relay combinations, combination starters, and enclosures. Sections are devoted to multiple pump controls, and overload heater tables and overload relays. 12 pages. B/W Controller Corp., 2211 E. Maple Rd., Birmingham, Mich. H

Circle 604 on Page 19

Teflon Shapes

Sizes and permissible tolerances of Teflon sheets, rods, tubing, tapes, and cementable etched tapes, as well as large diameter molded bars and cylinders are listed in Catalog TFE-359. Properties and end use applications are described. 8 pages. Cadillac Plastic & Chemical Co., 15111 Second Blvd., Detroit 3, Mich. H

Circle 605 on Page 19

Induced-Draft Fans

Bulletin L-1 points up features and dimensional information on Lehigh induced-draft fans. Units can be operated at 1000° F without damage to fan wheel, motor shaft, and bearings. 4 pages. Fuller Co., Lehigh Fan & Blower Div., Catasauqua, Pa. E

Circle 606 on Page 19

Magnesium Alloys

"Magnesium Alloys Improve Aircraft Performance" describes physical and mechanical properties of magnesium castings, sheet, and extrusions advantageous to airframe design. Aircraft, missile, and helicopter case histories are reviewed. 26 pages. Dow Chemical Co., Midland, Mich. H

Circle 607 on Page 19

Tantalum Capacitors

General description of solid tantalum capacitors, a list of possible applications, and data on performance characteristics are presented in Engineering Bulletin No. 1. Specifications for 60 different capacitors are listed. 4 pages. Kemet Co., Box 6087, Cleveland 1, Ohio. G

Circle 608 on Page 19

Rust-Preventing Liquids

"The A B C's of Rust-Lick" provides basic information on rust, its causes, and application of preventives. Factual data on various types of Rust-Lick rust preventing liquids and their recommended applications are included. 20 pages. Rust-Lick, Inc., 755 Boylston St., Boston 16, Mass. B

Circle 609 on Page 19

Beryllium Copper Alloys

Three data sheets furnish chemical analysis, physical constants, and mechanical properties of No. 10, 25, and 165 beryllium copper alloys. Instructions are given for forming, joining, pickling, rolling, and plating. 4 pages each. Brush Beryllium Co., Pennrold Div., 501 Crescent Ave., Reading, Pa. E

Circle 610 on Page 19

General Purpose Valves

Section N of new steel Catalog KS-1 covers line of small valves for general application. Needle and shutoff valves for working pressures up to 10,000 psi and operating temperatures up to 750° F are briefly described and specified. 4 pages. Kerotest Mfg. Co., 2525 Liberty Ave., Pittsburgh 22, Pa. F

Circle 611 on Page 19

Engine Tachometers

Details of a complete line of magnetic-drag tachometer indicators and tachometer generators for checking the speed of reciprocating or jet aircraft engines are contained in Bulletin GEA-6866. 12 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 612 on Page 19

Industrial Wheels

Load-carrying capacity, abrasion resistance, and tensile strength of 4 to 28 in. Disowheel polyurethane-tired wheels for industrial use are described in brochure. It outlines and illustrates possible applications. 4 pages. Disogrin Industries, Inc., 510 S. Fulton Ave., Mount Vernon, N. Y. D

Circle 613 on Page 19

Aluminum Bronze Extrusions

Typical chemical, mechanical, and physical properties of Wearite aluminum bronze extruded alloys 4-11 and 4-13 are furnished in bulletin. Standard extruded sizes available from stock are tabulated. 4 pages. Peninsular Steel Co., Box 3853, Detroit 5, Mich. H

Circle 614 on Page 19

Silicon Power Transistors

N-P-N diffused junction silicon power transistors, rated 85 watts, are subject of Bulletin DL-S 962. Performance, mechanical, and electrical data are presented. 6 pages. Texas Instruments Inc., Semiconductor-Components Div., Box 312, Dallas, Texas. P

Circle 615 on Page 19

Motor Starters

Bulletin 11-B1 introduces a new line of manual starters for motors rated up to 7½ hp ac and 2 hp dc. Controls feature a jog-run accessory, trip-free overload units, and simplified construction. 8 pages. Furnas Electric Co., 1045 McKee St., Batavia, Ill. I

Circle 616 on Page 19

Investment Castings

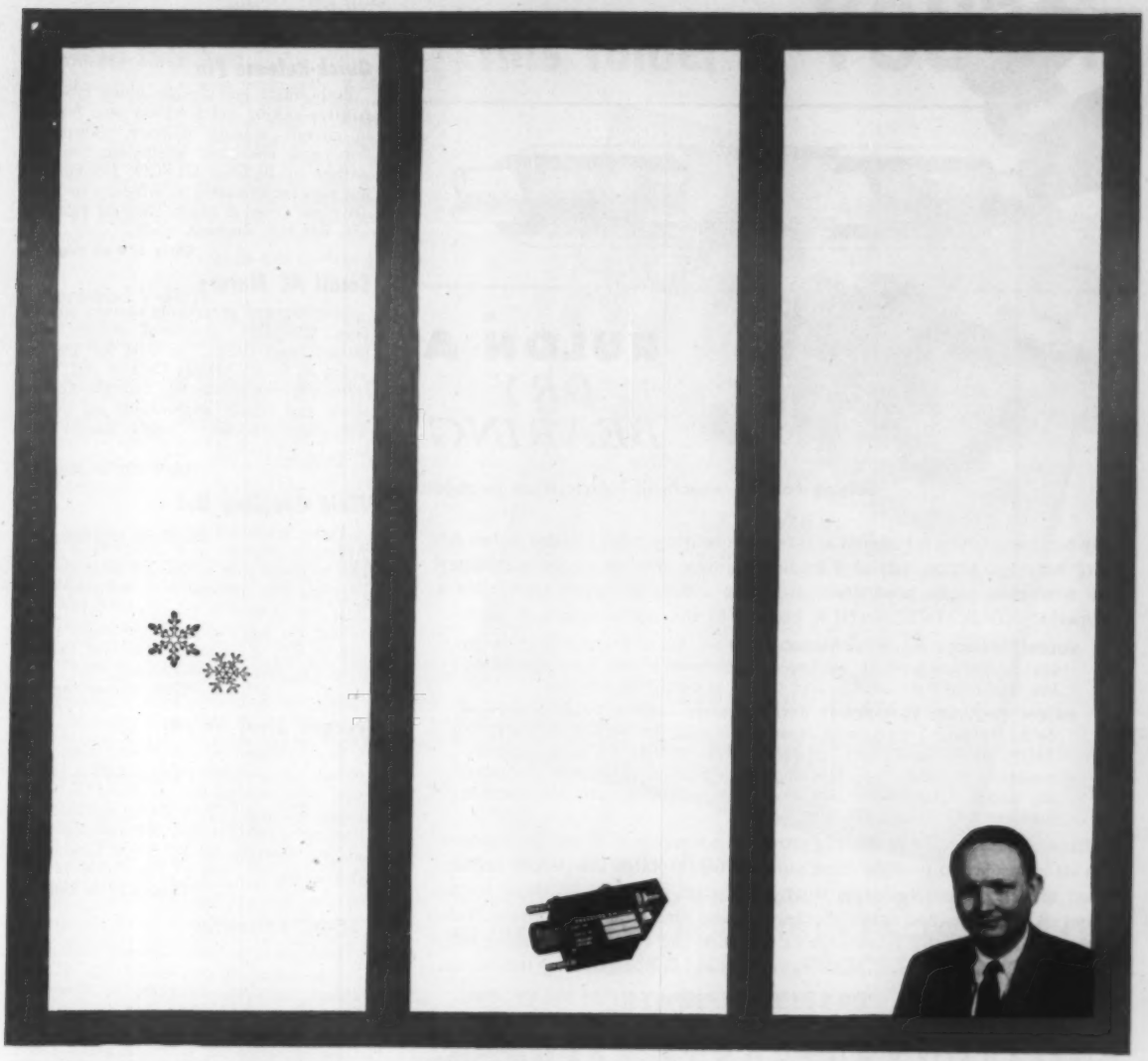
Facilities of this company for design and production of precision investment castings of aluminum and copper base alloys are detailed in illustrated bulletin. Various services available for custom-casting are shown. 4 pages. Rausch Mfg. Co., 750 Pelham Blvd., St. Paul 14, Minn. J

Circle 617 on Page 19

Servo Actuators

Three linear hydraulic servo actuators and one rotary hydraulic servo actuator are described and illustrated in four product data sheets. Design features and engineering data are given. 2 pages each. Lear Inc., Grand Rapids Div., 110 Ionia Ave. N.W., Grand Rapids 2, Mich. H

Circle 618 on Page 19



Wonders in Miniature. Snowflakes are excellent examples of how Nature uses tiny things to achieve great effects. Individually, these microscopic crystals are masterpieces of symmetrical beauty. Collectively, they have a decided influence on this planet's living conditions. Man follows Nature's lead by using miniaturization as a powerful force of action.

Miniature Pressure Switch, approximately 1¾″ long, has exceptionally high resistance to radiation. It maintains performance characteristics and calibration at 1000°F and in a reactor environment, operating in lines up to 10,000 PSI, with no seepage or leaks. Construction includes two MPB bearings to support movement of highly sensitive member.

Man With Miracles. Gordon Colson, an MPB Sales Engineer, worked closely with the firm producing the small high-pressure switch. He provided technical assistance for their engineers in selecting exactly the right bearings. To aid in solving your engineering problems with miracles in miniaturization, an experienced MPB technician is available.

New Miracles in Miniaturization

ACTUAL SIZE OF THE BEARINGS IN PRESSURE SWITCH SHOWN ABOVE

Reaching new heights, in outer space or in everyday industrial efficiency, calls for a good deal of new equipment, which usually calls for new miracles in miniaturization. And which, in turn, calls for experience like MPB's in making smaller bearings to meet greater scientific and industrial needs. MPB has specialized in this and produces over 500 types and sizes of bearings, ranging down to 1/10″ O.D., with specials as required. Our catalog will bring you complete facts on these. For catalog, or engineering advice, or both, **write Miniature Precision Bearings, Inc.,** 105 Precision Park, Keene, N. H.

MINIATURE PRECISION

MPB

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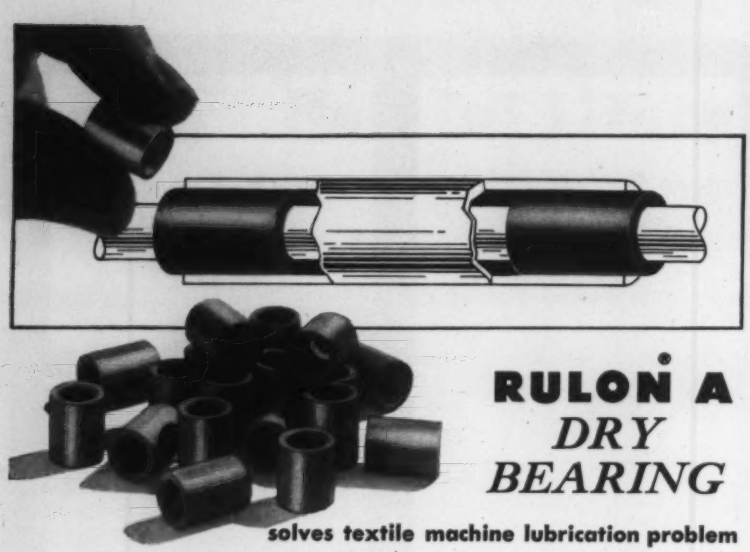
Helps you perform miracles in miniaturization

Circle 475 on Page 19



RULON A
DRY BEARING
solves textile machine lubrication problem

By replacing costly lubricated anti-friction bearings with no-lube **Rulon A*** dry bearings, Dixon helped a leading manufacturer of textile machinery to overcome major production problems and at the same time offer a superior NO MAINTENANCE bearing to the textile spinning trade.

RULON REDUCES MANUFACTURING COSTS — These bearings are low in cost . . . easy to press fit . . . simple to line-ream to size. Low cost Rulon bearings help the manufacturer to sell at competitive prices.

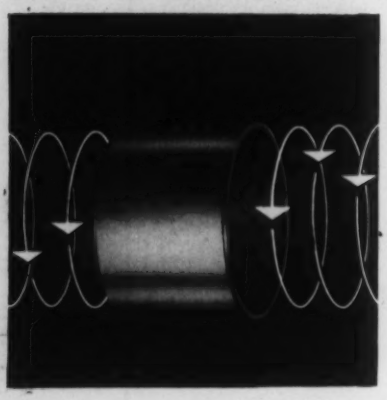
RULON PROVIDES IMPORTANT USER BENEFITS — Rulon bearings operate 24 hours/day, 6 days/week, year after year WITHOUT LUBRICATION. Shafts stay clean, oil free, LINT FREE . . . at no cost for maintenance! Rulon's low coefficient of friction guarantees low starting torque. User also avoids oil damage to cotton yarn — a constant problem with former bearings.

Dixon research and engineering groups are working with design engineers in all industries to provide these same savings through the proper application of Rulon shaft bearings, wear strips, cam followers, pushers, torque control bushings, and other mechanical and electrical components. Take advantage of Dixon's knowledge of standard and special reinforcing additives for Teflon . . . and molding, extruding, and machining techniques.

*One of Dixon's many modifications of Du Pont TFE Teflon

Write for Engineering Data Sheets on **RULON**
DIXON Corporation, Bristol, R. I.

Dixon Suppliers of basic shapes and fabricated parts in Rulon and Teflon



Shafts run smoother and longer on RULON T-LINER BEARINGS

Dixon's T-Liner Sleeve Bearing . . . with antifriction "floating" Rulon insert (modified TFE Teflon*) . . . is designed for applications that require high wear resistance with no lubrication. Available from stock in 10 standard sizes for ¼" to 1¼" shafts. Bulletin 32-T gives full details on coefficient of friction (low!), chemical inertness (high!), and price (low!). Write **Dixon Corporation, Bristol, Rhode Island.** *Du Pont TM

Dixon

Circle 476 on Page 19

HELPFUL LITERATURE

Quick-Release Pin

Both single and double acting types of positive-locking quick-release pins for use in aircraft, marine, military, transportation, and electronic equipment are described in Bulletin GEFCO. Double-acting pins are available in drive-out or non-drive-out types. 8 pages. General Fastener Co., Box 608, Burbank, Calif. L

Circle 619 on Page 19

Small AC Motors

Four types of alternating current, shaded pole, reversible, nongeared motors with ratings from 0.00015 to 0.04 hp are detailed in Small Motors Catalog R-1. Performance characteristics, ratings, dimensions, and typical applications aid in design considerations. 8 pages. Barber-Colman Co., Rockford, Ill. K

Circle 620 on Page 19

Fluid Coupling Nut

Tight, leakproof joints on critical fuel, hydraulic control, and other fluid lines can be made with a new self-locking fluid coupling nut announced in Bulletin 2488. Nuts are offered in sizes to fit ¼ to 1-in. tubing for services at temperatures ranging to 800° F. 4 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa. C

Circle 621 on Page 19

Forged Steel Unions

Specifications on all types, sizes, materials, and pressure ratings of W-S forged steel pipe unions are contained in illustrated Catalog U-2-58. Latest additions to line are Type 304 and 316 stainless steel unions. 8 pages. H. K. Porter Co., Forge & Fittings Div., Box 95, Roselle, N. J. D

Circle 622 on Page 19

AC-DC Voltmeter

Fifth digit for direct current over-ranging is feature of the Model 502 AC-DC digital voltmeter, described in illustrated Data Sheet 19-41. This digit doubles each range by extending it from 9999 to 19999. Detailed specs are given. 2 pages. Cohu Electronics, Inc., Kin Tel Div., Box 623, San Diego 12, Calif. L

Circle 623 on Page 19

Gearmotors

A selection of any single speed from ½ to 1000 rpm is offered in heavy duty Models HD1, HD2, and HD4 gearmotors described in bulletin. Units range from 1/65 to 1/20 hp and are used to power machine tools, pumps, and convevors. 2 pages. New England Gear Works, Meriden Avenue & South End Road, Southington, Conn. B

Circle 624 on Page 19

Silicon Carbide

High strength, erosion resistance, and high thermal shock resistance are properties of GRB silicon carbide (silicon carbide bonded graphite), subject of illustrated technical bulletin. Its properties, compositions, and results of typical tests are presented. 4 pages. Carborundum Co., Niagara Falls, N. Y. N

Circle 625 on Page 19

Stainless Strip Steel

Information on how martensitic stainless steels, usually alloyed with chromium and molybdenum, can be used in applications previously restricted to straight high carbon strip steels is presented in booklet. Analyses, heat treating, and applications are given. 16 pages. Uddeholm Co. of America, 155 E. 44th St., New York 17, N. Y. D

Circle 626 on Page 19

Open-End V-Belts

Written for those responsible for design, application, or maintenance of V-belt drives, Bulletin V-227 describes the use of Alligator V-belt fasteners in making up belts for any drive function. Factors such as belt length, tension, replacement, and selection are discussed. 6 pages. Flexible Steel Lacing Co., 4607 Lexington St., Chicago, Ill. J

Circle 627 on Page 19

Counting Devices

Data on construction, electrical characteristics and applications of Sodeco single-decade counting units given in illustrated bulletin offer solutions to various counting, telemetering, and automation problems. Schematics show typical uses of these electric impulse actuated decade counting units. 4 pages. Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y. D

Circle 628 on Page 19

Diesel Engines

"Quality Engines for the Original Equipment Manufacturer" is title of Booklet 20156 which explains factors governing selection of diesel engines for powering equipment serving the marine, petroleum, rail, military, mining, logging, and construction industries. Facilities and services of company are outlined. 16 pages. Caterpillar Tractor Co., Engine Div., Peoria, Ill. I

Circle 629 on Page 19

Magnetic Tape Recorder

Type 5-701 magnetic tape recorder for data acquisition systems features 14-track data recording, precision tape drive, self-contained power supplies, lightweight magnesium case, and all-metal recording heads. Unit is subject of descriptive Bulletin 1578A. 4 pages. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. L

Circle 630 on Page 19

Airflow Probes

Technical details on a line of calibrated airflow probes for measuring velocity, directions, pressure, and temperature of gases, liquids, and solids are found in illustrated Catalog 58. Specifications of all units are included. 8 pages. United Sensor & Control Corp., Box 127, Glastonbury, Conn. B

Circle 631 on Page 19

Finned Tubing

How a 13 per cent increase in outside surface area was obtained in Trufin Admiralty Type ST finned tubing is demon-

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Circle 477 on Page 19

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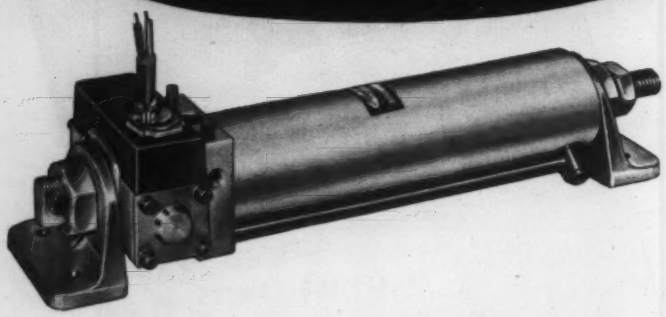

Here's a combination that's hard to beat—a performance-proved industrial air cylinder with its own built-in directional and exhaust speed control valves—in a single, compact "package". Check these important features:

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SOLENOID POWER REQUIRED: 10 watts
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SOLENOID COILS AVAILABLE: (ac) 8-10, 110, 220 v. (dc) 12, 24, 30 v.

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Circle 478 on Page 19

strated in Bulletin J 7383. Complete reference data on various types of this integral finned tube includes sizes, alloys, heat transfer rates, and application information. 24 pages. Calumet & Hecla, Inc., Wolverine Tube Div., 17200 Southfield Rd., Allen Park, Mich. H

Circle 632 on Page 19

Mo & Mo-Ti Alloys

Pricing schedule for molybdenum and molybdenum-titanium alloys covers billet, clad molybdenum sheet, close tolerance bar, foil, forgings, ingot, plate, rectangular bar, round bar, sheet, sheet bar, and swaged bar. 24 pages. Universal-Cyclops Steel Corp., Refractomet Div., Bridgeville, Pa. F

Circle 633 on Page 19

Gear Train Packages

"Universal A to Z Design for Unlimited Package Assemblies" is title of illustrated booklet on instrument plates and cluster gears. How they can be assembled in an endless variety of combinations is detailed. 20 pages. PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 634 on Page 19

Readout Lamps

"Rayescent Readout Lamps" is title of folder discussing the phenomenon of electroluminescence and its application to lamps for display of continually changing numerical or alphabetical information. Mechanical, electrical, and visual characteristics are summarized. 4 pages. Westinghouse Electric Co., Lamp Div., MacArthur Avenue, Bloomfield 7, N. J. D

Circle 635 on Page 19

Mounting Systems

Space-age capabilities in the field of engineered systems for shock, noise, and vibration control are described in illustrated Bulletin 714. Examples of standard, special, and high performance mounting systems are detailed, as are company experience and facilities. 12 pages. Lord Mfg. Co., Erie, Pa. F

Circle 636 on Page 19

Switchboard Instruments

Thirteen types of switchboard instruments, including ac and dc ammeters, milliammeters, voltmeters, and watt meters, plus frequency meters, synchroscopes, power factor meters, VAR meters, and temperature indicators are covered in detail in Catalog 4220. Accessories are included. 24 pages. Roller-Smith, Inc., 50 Ave. L, Newark 1, N. J. D

Circle 637 on Page 19

High Speed Gear Drives

A complete range of high speed gear drives for test stands, industrial applications, and pipeline and air conditioning service is covered as to engineering details, dimensions, and ratings in Bulletin 5904. Drives capable of up to 50,000 rpm and 50,000 hp are shown. 20 pages. Request on company letterhead from Western Gear Corp., Industrial Products Div., Box 126, Belmont, Calif. L

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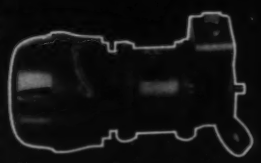
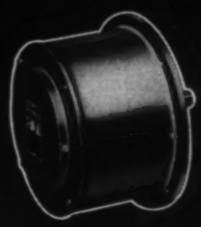
Standard Open Drip-proof
Frames 56 thru 326U



Explosion-proof Torque
Motor with Brake
Frames 56 thru 326U



Spacesaver
Frames 56 thru 286U

Weather-tight Special Flange
Frames 56 thru 326U

RATINGS FROM 2 OZ. IN. to 200 LB. FT.

NEW TORQUE BULLETIN
This bulletin outlines basic facts about Peerless torque motors and shows applications. It is available FREE. Write for it today.

These Peerless torque motors deliver maximum rated torque without damage to the windings when stalled across the line at full voltage for predetermined periods. Peerless also builds torque motors which provide a nearly constant torque while operating at less than synchronous speeds.

All standard frame sizes; all types of mountings; high torques; special paint and varnish treatments; and Class A, B, F, and H insulation are available at Peerless. The special attention and close cooperation required on torque motor design and application have made Peerless a leader in the field. Give your torque motor problem to the Peerless engineers. They'll work with you to develop the torque motor that powers your product best.

ELECTRIC MOTOR DIVISION

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Circle 479 on Page 19

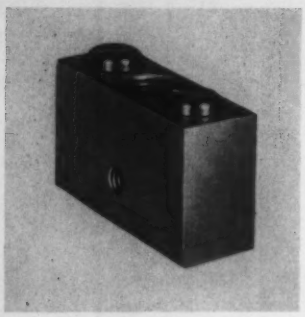
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Valve

double-ball check unit is for pressures to 100 psi

Check valve, No. 9061, is a miniature unit which utilizes a separate ball for each inlet. If both supply pressures fail, two inlets are immediately sealed, preventing bleed-off of downstream pressure. High pressure of one inlet shuts off low pressure of alternate inlet and holds it



closed until pressure of second inlet becomes higher of the two. Body is rated for 100 psi maximum and temperatures to 300 F. **George W. Dahl Co. Inc.**, 86 Tupelo St., Bristol, R. I. B

Circle 638 on Page 19

Clutches and Brakes

miniature units fit standard shafts

Redesigned miniature clutches and brakes use face gear, pinion, or coupling drives for adaptation to most existing applications. S-750, illustrated, can be used with a pinion for 90-deg drive or with a coupling for in-line drive. Clutches and brakes fit standard shafts and can be used on standard breadboard setups. All face gears and pinions are precision machined, and clutch can be driven by standard mating pinions. Available in coil voltages from 3 to 100 v, unit shown

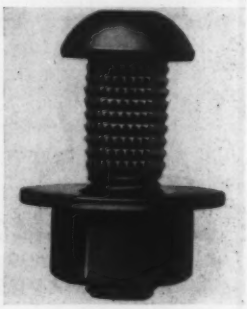
delivers 10 oz-in. minimum torque and has engagement time of less than 7 millisec. Clutches and brakes are used to control potentiometers, counters, servos, and computer integrators. They are used also in control instrumentation, missiles, and machine control. **Norman Hardy Associates**, P. O. Box 97, Wyncote, Pa. E

Circle 639 on Page 19

Structural Bolt

has high shear strength and resistance to slip

High-strength structural bolt combines tensile strength of a hex-head, high-strength bolt with bearing of a rivet. It has high shear strength and excellent resistance to slip. Shank is made with specially formed knurls, set on a spiral which reduces driving load. Length of knurled body is determined by thickness of members to be joined. When bolt is driven or pulled into place, knurls produce a body-bound fit. Button-head shape of bolt head



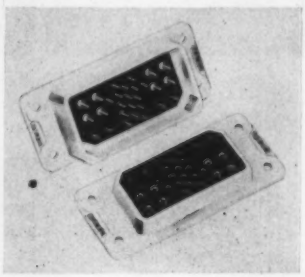
provides equivalent bearing area of a comparable hex-head, high-strength bolt, plus a washer. Bolt is easy to drive or pull into position, since frontal shape of each knurl is a section of a small ball, back face is relieved somewhat like a drill or tap to prevent packing of displaced material, and knurls are set on a spiral to reduce driving force. Bolt, of heat-treated, high-carbon steel meeting ASTM A325 specifications, can be assembled wherever a conventional high-strength bolt can be used in punched or drilled holes. **Lamson & Sessions Co.**, 5000 Tiedeman Rd., Cleveland 9, Ohio. G

Circle 640 on Page 19

Miniature Connectors

rectangular units have closed entry contacts

Heavy-duty rectangular connectors, named Series 2000, are available in three contact arrangements for vari-



ous power applications requiring combinations of coaxial and conventional contacts, contacts for No. 16 and No. 18 AWG wire, and 41 contacts for No. 18 AWG wire. Self-aligning polarizing shells with integral mounting plate are constructed in one piece of die-cast aluminum, cadmium plated. Shells have corner keying design to prevent mismatch and provide easy engagement of plug and receptacle. Closed-entry contacts with leaf spring provide increased reliability and main-

for strength, corrosion resistance and safety...

it had to be Stainless

This window washer anchor is fabricated from Carpenter Stainless No. 4-A (Type 304) for use with window hardware on skyscrapers in large cities. Men attach their safety belts to these anchors while washing the windows. Stainless is used for maximum corrosion resistance and strength in atmospheric conditions. In fabrication, the forging bars must flow freely without tendency to rupture. Since switching to Carpenter, the forging shop has reduced rejections because of the cleaner, defect-free surfaces. The Carpenter representative near you can supply close metallurgical cooperation and complete technical data on your stainless requirements. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

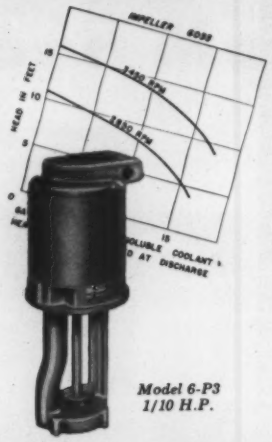
Carpenter STEEL

The Carpenter Steel Company
Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

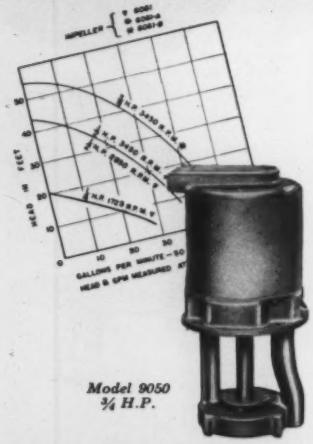
Machine tool builders know...

No matter what size . . .

Yes, there is a Ruthman Gusher Coolant Pump that will exactly fit your coolant pump requirements from the P-3 Series (Baby Gusher) with 1/10 H.P. to the largest 7½ H.P. Series. Gusher Pumps are available in Immersed, Pipe Connected, Flange Mounted and Tank Units.



Model 6-P3 1/10 H.P.



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1811 Reading Road **Cincinnati, Ohio**

Circle 481 on Page 19

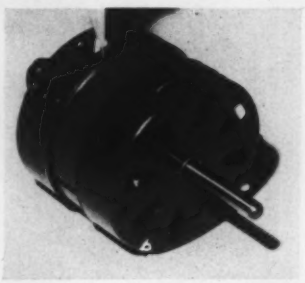
tain low millivolt drop under constant and uniform insertion pressure. Current rating is 7.5 amp for 0.058 diam solder cup and 10 amp for 0.076 in. diam solder cup. **Electronic Sales Div., DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 641 on Page 19

Small Electric Motors

have sheet-metal end bells glued to motor stator

Unitized motors have bearing housings mounted on end bells with high-strength epoxy resin. End bells are slipped over stator frame, and clearances between end bells and stator are filled with resin. Motors cannot be taken apart after resin



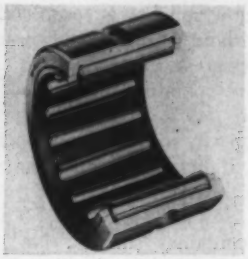
sets. Motors are available in four-pole, KSM, 59-frame shaded-pole and permanent-split-capacitor ratings up through 1/15 hp. Two-pole shaded-pole units with ratings through 20 milli-hp and universal series motors of various ratings will also be available. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 642 on Page 19

Needle Roller Bearings

for use where misalignment is excessive

Standard stock sizes have been added to MR series of Cagerol cage-type needle roller bearings. Bearings are available in 15 standard stock sizes in outer-ring and roller assemblies with separable inner rings. They are also available from stock in 11 sizes without separable inner rings. New sizes with separable inner ring are available in shaft diameters from 0.5 to 2.5 in., and stock bearings without separable inner ring range from 0.75 to 3 in. Bearings carry needle-type



roller-bearing loads in applications where misalignment and shaft deflection are excessive and not easily controlled. Design provides continuous tubular cage, and spaces and locates load-carrying rollers to insure positive alignment and prevent heat increases at high speeds. **Bearing Div., McGill Mfg. Co. Inc.,** Valparaiso, Ind. J

Circle 643 on Page 19

Magnetic Plastic

flexible vinyl can be magnetized in any direction

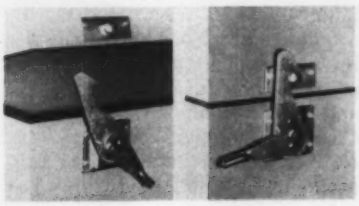
Koroseal flexible vinyl plastic reacts like metal or ceramic magnets. It can be produced in continuous lengths in a variety of shapes, and cutting does not impair magnetic qualities. Attracted to ferrous metals or to itself, material can be furnished with poles at opposite ends, across the thickness, across the width, or side-by-side. It can be extruded in any shape, and can be spot or shape magnetized for special applications. It is an electrical insulating material which retains magnetic ability well and is chemically inert. **B. F. Goodrich Industrial Products Co., Div., B. F. Goodrich Co.,** Marietta, Ohio. F

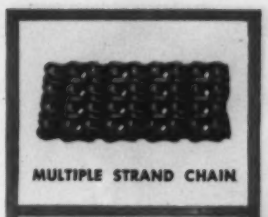
Circle 644 on Page 19

Container Latch

has 750-lb load-carrying capacity

Latching device for use on rigidly specified military cases and com-





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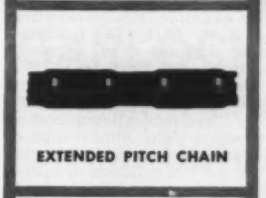

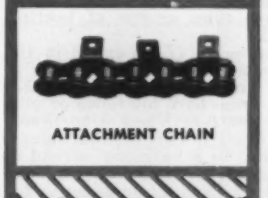

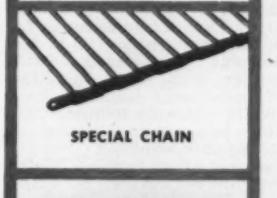

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ROLLER CHAIN and SPROCKETS
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Circle 482 on Page 19

BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.

WHY CLASS ABEC 7 BEARINGS?

Improved Running Quality in critical applications is the reason why the Annular Bearing Engineers Committee of the Anti-Friction Bearing Manufacturers Association, Inc., has established Class 7 as the highest United States standard for manufacturing tolerances of miniature ball bearings. Originally available only on order . . . and at premium prices because of selection from ABEC 5 production runs . . . ABEC 7 bearings are now offered by New Hampshire Ball Bearings, Inc., as its minimum standard . . . at no extra charge.

An item-by-item comparison of ABEC 5 and ABEC 7 standards clearly shows how closer tolerances improve running quality.

(COMPARATIVE CHART)

RING		MEASUREMENT	TOLERANCES ABEC 5	TOLERANCES ABEC 7
Both	1.	Radial Runout (TIR) Max.	.0002"	.0002"*
Inner	2.	Side Runout with Bore	.0003"	.0001"
Outer	3.	O. D. Runout with Side	.0003"	.00015"
Both	4.	Parallelism of Sides	.0002"	.0001"
Inner	5.	Groove Parallelism with Sides	.0003"	.0001"
Outer	6.	Groove Parallelism with Sides	.0003"	.0002"
Inner	7.	Bore (I.D.)	+.0000" −.0002"	+.00000" −.00015"
Outer	8.	O.D.	+.0000" −.0002"	+.0000" −.0002"**
Both	9.	Width (Individual Rings)	+.000" −.005"	+.000" −.005"***

*ABEC 7 allows .0002" radial runout for outer ring. We hold it to .0001".
**We hold it to −.00015"
***We hold it to −.001"

Radial Runout . . . the sum of a ring's out-of-roundness and eccentricity . . . is functionally important. In critical high-speed applications, it affects balance and true running. In precise gear trains, it affects backlash and sometimes angular velocity ratio. In closely designed synchros and similar electrical equipment, it affects air gap control. Since most bearings operate with inner ring rotation, you'll notice that ABEC 7 cuts the ABEC 5 allowance in half . . . from .0002" max. to .0001". For the outer ring ABEC 7 makes no change from Class 5's .0002" max. However, modern race grinders work to a nominal zero runout and .0001" max. may usually be expected. Our inspection tolerance, therefore, is .0001". This gives outer-ring rotation applications the same advantages as for inner-ring rotation.

Perpendicularity of raceway planes to axis of rotation is a highly desirable feature. Its probability is determined by the interrelationship of Side Runout with Bore (Inner Ring), O. D. Runout with Sides (Outer Ring), parallelism of sides and groove parallelism with sides of both rings, when bearings are properly mounted and seated. If raceway planes are not perpendicular to the axis of rotation, stresses and torque peaks will be developed within the bearing because of this misalignment unless radial clearance and enlarged raceway curvature are sufficient to compensate. This effect may be observed in clamped, preloaded duplex bearings by shifting the relative position of the rings, reclamping and feel-testing.

Notice that the five perpendicularity features (2 through 6 in the chart) have much lower allowances in ABEC 7 than in ABEC 5. These differences in angular inaccuracy mean much in running quality as bearings become smaller. For example, non-parallelism of .0002" on a ⅜" O.D. (R 2 bearing) represents an angular error of about 2 minutes. But, on a 3/16 O.D. (R 1 bearing), the same allowance means 4 minutes of angular error. That's why ABEC 7 reduces allowances by one half or more. The importance of minimizing angular error is also reflected in the AFBMA tables of allowances, which are generally reduced within each class as size of bearing is reduced.

Envelope Tolerances (7, 8, and 9 in the chart) make little or no difference in running quality. The only ABEC change is from bore tolerance of plus 0, minus .0002 in Class 5 to minus .00015 in Class 7. This permits mounting bearings to a narrower spread of fits. Although ABEC 7 allows the same O.D. and width tolerances as for ABEC 5, we have reduced O.D. tolerance to plus zero, minus .00015" and, together with other manufacturers of instrument bearings, have reduced width tolerance to minus .001. The latter minimizes variation in axial spacing of assemblies.

Other Factors that affect running quality of bearings are not covered by ABEC standards. They include: truth of raceway geometry, surface finishes, retainer design and finish, radial and axial play and some ball qualities. These are discussed in our design handbook.

DESIGN HANDBOOK OFFERED FREE

You'll find this up-to-the-minute, authoritative 70-plus-page publication a great help in designing instruments or small electromechanical assemblies. Write to New Hampshire Ball Bearings, Inc., Peterborough 1, N. H.

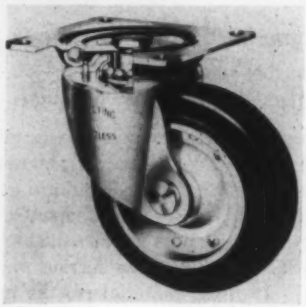
NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

mercial containers is positive-locking without springs, and provides closing pressure of 200 lb with standard operating lever. Designated Hook Lock, unit has load-carrying capacity of 750 lb. Open or closed, it lies flat against container on which it is mounted. At thickest point, fastener extends 7/16 in. from container surface. No space for operating clearance is required, since operation is parallel to mounting surface. Lock is impact and shockproof, and is unaffected by arctic temperatures. **Simmons Fastener Corp.**, North Broadway, Albany 1, N. Y. D

Circle 645 on Page 19

Swivel-Plate Casters

for loads to 2000 lb



Medium-duty, Series L900 swivel-plate casters are made with 5, 6, and 8-in. wheels and a wide range of threads to meet requirements of any floor surface or operating condition. They are designed for trucks and portable equipment carrying loads up to 2000 lb. Features include hardened, double ball-bearing swivels, and grease-retaining and bearing-protecting cups. **Faultless Caster Corp.**, 1421 N. Garvin St., Evansville 7, Ind. J

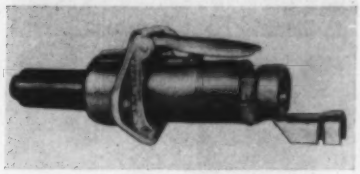
Circle 646 on Page 19

Electrical Connector

transmits heavy-duty electric power

Battery-capacity electrical connector, designated No. 11040, transmits heavy-duty current to start and power all types of industrial engines and other motorized equipment. Connector accommodates No. 0, 1, or 2-gage cable, and is currently available for installation with stand-

Circle 483 on Page 19



ard lengths of No. 1 gage cable and attached lugs. It is economical, easy to install, and has capacity for long life. Cole-Hersee Co., 20 Old Colony Ave., South Boston 27, Mass. B

Circle 647 on Page 19

High-Temperature Lubricant

for temperatures to 1000 F

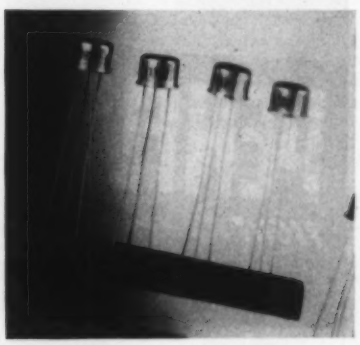
Industrial lubricant is composed of an organic thickener, synthetic carrying agent, and solid lubricant. Carrying agent burns after depositing lubricant, and loss of carrier does not affect lubricity or other properties of the soft graphite film formed. Hi-Temp 2409 can be applied manually or automatically. Lubricant is useful in a broad range of industrial applications at temperatures to 1000 F. **E. F. Houghton & Co.**, 303 W. Lehigh Ave., Philadelphia 33, Pa. C

Circle 648 on Page 19

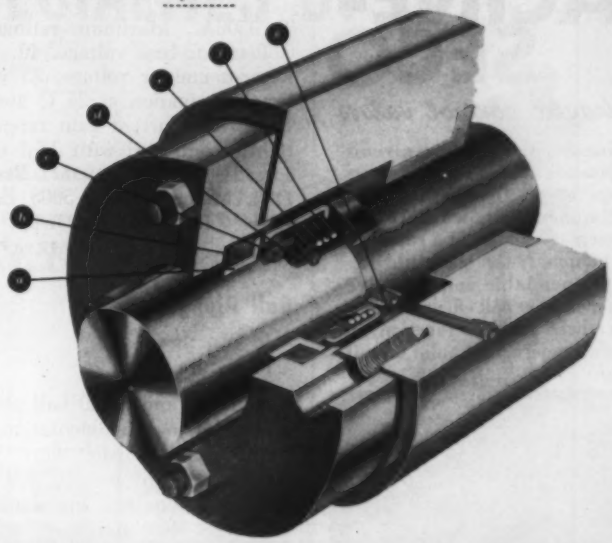
Germanium Transistors

for general-purpose use in audio-frequency range

Low-cost, germanium audio transistors, types 2N1191, 2N1192, and 2N1193, are PNP alloy-junction units designed for general-purpose applications in the audio-frequency range, including both amplifier and switching service. Internal construction and hermetically sealed industry standard TO-9 package meet or exceed mechanical and environmental requirements of MIL-



ONE OF THE GARLOCK **2,000**



GARLOCK Mechanical Seals —self-contained for easy installation, less downtime

a. ***Stationary Seat*** *of ceramic, Ni Resist, or bronze has precision lapped sealing face for perfect contact with carbon ring.*

b. ***Vibration Ring*** *of Buna-N positions stationary seat in a flexible mounting and acts as static seal.*

c. ***Seal Ring*** *of carbon is also precisely lapped to match sealing face of stationary seat.*

d. ***Roll type Bellows*** *permits free movement of seal ring.*

e. ***Shell,*** *encases entire rotary unit and furnishes mechanical drive for seal ring.*

f. ***Stainless Steel Spring*** *with load precisely calculated to face area of seal.*

g. ***Stop Collar,*** *or shoulder, positions seal to specified operating length.*

Garlock's PK MECHANIPAK* is designed to avoid excessive downtime. Self-contained, it can be installed simply and quickly, and eliminates adjustment during operation. Seal life is equal to many sets of conventional packings. Check these additional advantages:

Leak-proof sealing. Sealing faces of rotating and stationary parts are precision lapped for perfect contact, thus preventing leakage.

Elimination of shaft wear. No parts of the seal move on the shaft or sleeve, thus removing the danger of scoring or wear.

Maximum operating conditions are 212° F temperature, 150 psi pressure, 2000 fpm shaft speed. Available in shaft sizes from ⅜" to 3", PK MECHANIPAK Seals are another of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Find out more by talking with your local Garlock representative, or write for Catalog AD-150.

*Registered Trade Mark

THE GARLOCK PACKING COMPANY, Palmyra, N.Y.

FOR PROMPT SERVICE, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

CANADIAN DIVISION: The Garlock Packing Co. of Canada Ltd.
PLASTICS DIVISION: United States Gasket Company

Circle 484 on Page 19

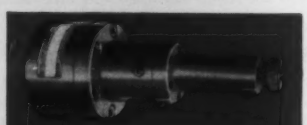
RACINE-SECO

Hydraulic control valves

Racine-Seco hydraulic circuit components are the result of years of experience in engineering and development. Shown here are representative types of a complete line of quality-designed, quality-built dependable control valve equipment that will efficiently perform their specific function in today's modern hydraulic circuit design.

DIRECTIONAL CONTROL VALVES
Mechanical, manual, pilot and electrical operation available in 2 way and 4 way valves — foot and panel mounting. Sizes ¼" to 2" — 1500-2000-3000 PSI.

VOLUME CONTROL VALVES
For maintaining constantly-metered flow regardless of pressure fluctuations in either the inlet or outlet ports of the valve. Capacities from 5 cu. in./min. to 60 gpm. Sizes ¼" to 1¼" I.P.S.



PRESSURE CONTROL VALVES
Precision control of pressures up to 10,000 PSI. Complete line includes Relief, Unloading, Sequence, Counter Balance, Reducing and Resistance Valves. Capacities up to 60 gpm.

All RACINE-SECO *Hydraulic Control Valves are designed to conform to J.I.C. specifications. Write for complete descriptive Catalog 59-A.*

RACINE SECO

RACINE HYDRAULICS & MACHINERY, INC.
2073 Albert Street RACINE, WISCONSIN
One Source — One Responsibility
FOR ALL YOUR HYDRAULIC NEEDS

Circle 485 on Page 19

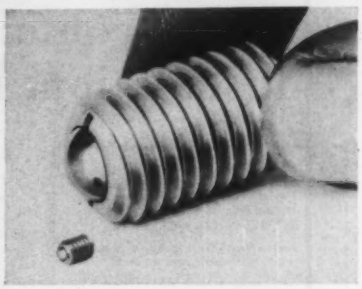
T-19500A. Maximum ratings are: Collector-to-base voltage, 40 v; collector-to-emitter voltage, 25 v; collector dissipation at 25 C ambient, 175 mw. Current gain ranges are tightly controlled with 2.5:1 or less spread. **Semiconductor Products Div., Motorola Inc.,** 5005 E. McDowell Rd., Phoenix, Ariz. L

Circle 649 on Page 19

Ball Plungers

in two new miniature sizes

Sizes 10-32 and ¼-20 ball plungers are useful in instrumentation, electronics, and missile work where small size, light weight, and reliability are required. Standard balls are type 440 hardened stainless steel. Balls of high carbon chrome alloy, K-monel, aluminum, tobin



bronze, carbon steel, glass, nylon, carbides, copper, and other special materials can also be furnished. Bodies are available in black oxide, cadmium, or gold plating. **Vlier Engineering Corp.,** 8900 Santa Monica Blvd., Los Angeles 46, Calif. L

Circle 650 on Page 19

Miniature Relay

resists shock to 50 g and vibration to 10 g

Sensitive relay is intended for dc operation at sensitivities from 20 to 100 mw. Where shock and vibration are negligible, sensitivity of 15 mw per pole is available. Contact rating with resistive load at 28 v dc or 115 v ac is 3 amp (silver contacts) or 0.5 amp (palladium or gold alloy). Operating temperature is −55 to 100 C with −65 to 125 C available on order. Unit resists shock to 50 g and vibration to 10 g from 10 to 500 cps. Designated Type TQA, unit is also avail-

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Has The Answer

. . . with a complete line of all types and sizes of flexible metallic tubing . . . plus "Flexineering." That well-known technical help of Penflex engineers on your specific design, application and installation . . . plus the "know-how" to supply just the right flexible tubing you need.

Whether you need steel, bronze or stainless-steel to convey air, oil, water, gas, steam, volatiles or light solids, Penflex has the answer. Its complete line of corrugated and interlocked tubing is rugged, safe at high pressures and temperatures. Write for complete data to Pennsylvania Flexible Metallic Tubing Co., Inc., 7239 Powers Lane, Philadelphia 42, Pa.

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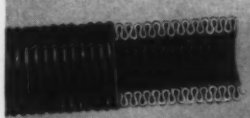
Write for your copy.

Penflex Interlocked Hose



Penflexweld All-Metal Tubing

PENFLEX
TIGHT AS A PIPE BUT...
FLEXIBLE

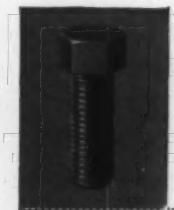
Circle 486 on Page 19

FASTENING SPECIALTIES BY *National*

Get more dependable holding

power for better product assembly with these

National SPECIALTY FASTENERS!



Lok-Thred® Bolts, Studs, Screws—Seal and lock against involuntary loosening... Lok-Thred re-forms the metal of the receiving thread under high compressive stresses into intimate contact with itself, eliminating all voids. Yet, it's fully re-usable. Requires no selective fits. Can be used with ordinary tools. Available in all sizes of bolts, studs, screws... No. 6 or larger.

Spin-Lock® Fasteners—Give you strength at low cost, with self-locking, ratchet-tooth action... Spin-Lock machine and tapping screws have angled teeth to permit fast, easy tightening. They require about 20% greater torque to loosen. Available in pan, truss, flat and hex heads; slotted or Phillips recessed heads; No. 4 to ⅜" diameters, lengths from twice diameter and up.

Thread Cutting Screws—For joining metals or plastics without tapping... Use wherever it is desirable to remove rather than displace thread material. Four types: 1, 23, 25, and F cover most applications. Phillips or slotted heads, all styles, all sizes. Also type A and B tapping screws for fastening light sheet steel or light gauges of other metals.

Lock Nuts—Three types, to meet every requirement... 1. *Huglock*, for locking without seating and under adverse conditions. 2. *Marsden*, free-running until seated... for minimum-cost locking. 3. *Drake*, a two-piece design for use under severe stresses, shock, vibration. All types are all-metal, fully re-usable without loss of positive locking action.

Welding Fasteners and Weldnuts—Provide trouble-free assembly of fabricated metal parts... Use National welding fasteners when primary fasteners must be cleanly welded into exact position. National's complete line of projection welding screws and nuts is available in stock sizes, for optimum welds in materials .030 to ¼" thick. We will develop special designs for you.

Flex-Head® Locking Screws—Self-locking, highly resistant to fatigue, shock, impact... Tight locking results from flexing of the head and axial spring tension produced when fully torqued against a rigid seat. Flex-Head screws are identical in dimension, and interchangeable with standard machine screws. Made of 1022 steel and heat-treated for top strength.

Tuff-Tite® Cushioned Fasteners—Seal openings, eliminate vibration noises, absorb shock... Pre-assembled neoprene washers also prevent finish marring! Available as tapping screws, thread cutting screws, machine screws, roofing bolts, stove bolts, or wood screws; with Phillips or slotted heads; pan, round, truss or hex head styles.

Place® Bolts—Self-locking...resist impact, shock and fatigue failure by controlled spring action of reinforced, diaphragm head... Place bolts resist involuntary loosening when rigidly seated. Typical uses: connecting rod bolts, main bearing cap screws, flywheel bolts. Available in high carbon or alloy steel, in a wide range of sizes.

Save yourself time and trouble in searching for the right fastener. Make National your *one source* for standards, specialties and special designs. Our standard line includes all types and sizes... nuts, cap and set screws, machine bolts, carriage, step and elevator bolts, plow bolts; Phillips recessed head, or slotted, Sems, machine screws, wood screws; stove bolts, pipe plugs, cotter pins and rivets.

National can supply any nonstandard fastener, or design and produce specials for you. Write for National's *Special Products* booklet, or for information on the fastening specialty that interests you.

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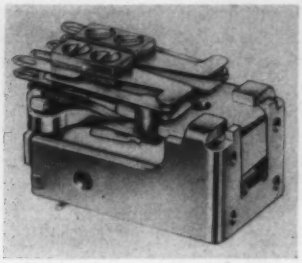


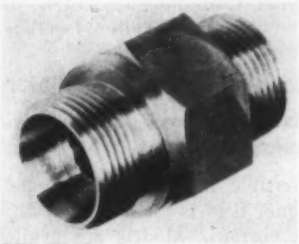
able in hermetically sealed enclosure as Type TQAH. **Comar Electric Co.**, 3349 W. Addison St., Chicago 18, Ill. J

Circle 651 on Page 19

Hydraulic Check Valves

miniature units have low pressure drop

Sized to fit envelopes of proposed specifications MS 24424 and MS 24423, miniature hydraulic check valves offer ports for both flared and flareless tubing connections. Design features positive internal locking of spring guide, allowing universal application, since no washout of pressed-in parts is possible. Valves provide weight and space savings with low pressure drop for aircraft and missile hydraulic system use. Sizes 4 through



16, in both stainless steel and aluminum, are qualified for Type II system use. Stainless-steel valves in each port configuration are suitable for Type III system use. **Hydraulic Div., Parker Aircraft Co.**, 5827 W. Century Blvd., Los Angeles 45, Calif. L

Circle 652 on Page 19

Floating Dome Nut

redesigned unit is 35 per cent lighter

Two-lug, self-sealing, floating dome nut in 5/16-24 thread size, designated No. 14634H-054, is 35 per cent

You save 5 ways with

SHENANGO CENTRIFUGAL CASTINGS

By using Shenango centrifugal castings for essentially symmetrical parts, you will gain considerable savings because:

1. **The Shenango process automatically eliminates hidden defects in the metal . . . insures fewer rejects.**
2. **No patterns required . . . an important saving, particularly on special or small quantity runs.**
3. **Finer, more uniform grain structure means smoother, faster machining, better control, and a higher rate of completion.**
4. **With Shenango centrifugal method control, there's less excess metal to be machined away, less metal to buy and ship!**
5. **Because of their homogeneous, pressure-dense qualities, Shenango centrifugal castings are stronger, have better wear resistance and require less frequent replacement. Maintenance cost is cut!**

Check with Shenango on centrifugally cast parts for your needs —large or small castings . . . rough, semi-finished or precision-machined . . . ferrous or non-ferrous. They'll cost you less in the long run. For bulletins, write to: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, Ohio.

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COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

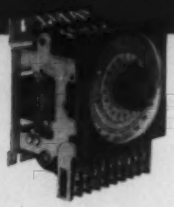
Circle 489 on Page 19

Count Control

COMPONENTS

FOR AUTOMATING INDUSTRIAL PROCESSES

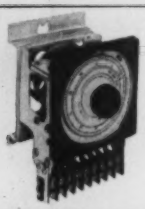
featuring adjustable count automatic-reset 10 ampere switches



model HZ4
MICROFLEX RESET COUNTER

Use to control an operation for a preset number of counts. Has spring reset to "0." Dial ranges 19, 400 and 1,000 counts.

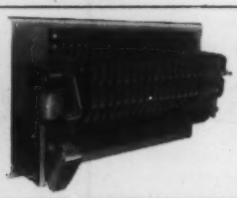
Ask for bulletin 720.



model HZ200
ADD-SUBTRACT COUNTER

Add-Subtract counter — operates from ADD pulses which trip switch at maximum limit — and SUBTRACT pulses which trip switch at "0" limit.

Ask for bulletin 740.



model MT
STEP SWITCH

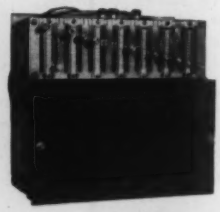
Use for sequence control from pulses — 19 contacts — 60 cycle coil-break out cam lugs.

Ask for bulletin 780.

model HZ6
MICROFLEX REVOLUTION COUNTER

Use to control an operation as a function of mechanical movement — drive shaft can be mechanically connected to machine, spindle, conveyor, etc.

Ask for bulletin 730.



model HM
MULTIFLEX (Multiple Circuit) TIMER

Use for sequence control of 1 to 7 circuits. With shaft drive for mechanical connection to an external drive mechanism.

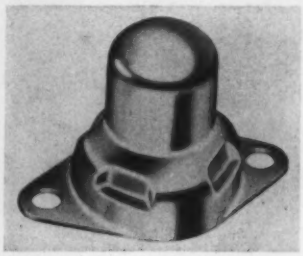
Ask for bulletin 130.

Write us regarding your count problem. Services of Sales Engineers in 25 district offices are available without obligation. Address Dept. MD-559.

EAGLE SIGNAL CORPORATION

MOLINE, ILLINOIS

Eagle Timers Save Time—Save Money



lighter than previous model. It is also 100 per cent stronger in torque-out, and narrower envelope makes it useful in areas where space is limited. **Nutt-Shel Co.**, 2701 S. Harbor Blvd., Santa Ana, Calif. L

Circle 653 on Page 19

Vinyl Sheeting

has nonstaining finish

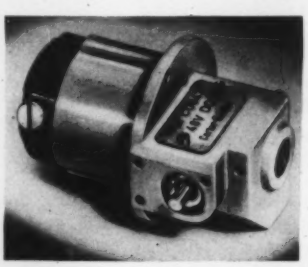
Colovin vinyl sheeting, which can be laminated to steel, aluminum, and other metals, is now available with nonstaining finish. All stains tested have proved removable from the finish, including black and red hair dye, ball-point pen ink, iodine, and gentian violet. Developed primarily for use with white vinyl, finish is also available in any other color, multicolored combinations, and textured effects. **Columbus Coated Fabrics Corp.**, 7th at Grant Avenue, Columbus 16, Ohio. G

Circle 654 on Page 19

Fractional-Horsepower Motor

has shaft speed as low as 10 rpm

Reversible motor with permanent-magnet field is for operation on direct current. Models are available for various inputs from 6 to 48 v dc, and with output shaft speeds of 10 to 100 rpm, obtainable through built-in double gear reduction. Heavy center bearing and oversize shaft at center prevent misalignment or whip at armature end. Ac-



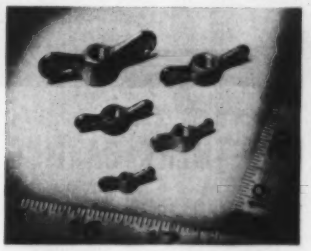
cessibility of brush and commutator parts is rendered free of obstruction. Over-all length of Model CO-843 is about 2⅞ in., and output torque is 50 oz-in. maximum. Motor frame and gear case are die-cast aluminum. **Carter Motor Co.**, 2719A W. George St., Chicago 18, Ill. I

Circle 655 on Page 19

Low Wing Nuts

zinc-alloy units are die cast

For use where low wing height is needed or where projection of a standard wing nut might introduce a snag problem, die-cast low wing nuts are supplied in thread sizes from No. 5 through ⅜ in. in wing



spreads of 13/16 to 1⅞ in. Typical applications include portable tools, instruments, paint rollers, air and oil filters, tripods, and display cases. For specific applications, fasteners can be obtained with various blank modifications, such as nonstandard thread, beveled and rounded seats, keyways, special bosses and counterbores, or hole in one wing. Serrated bases are also available and provide for self-locking action in aluminum, wood, plastic, and other soft materials. All threads meet unified thread specifications, Class 2B, and units are rustproof. **Gries Reproducer Corp.**, 125 Beechwood Ave., New Rochelle, N. Y. D

Circle 656 on Page 19

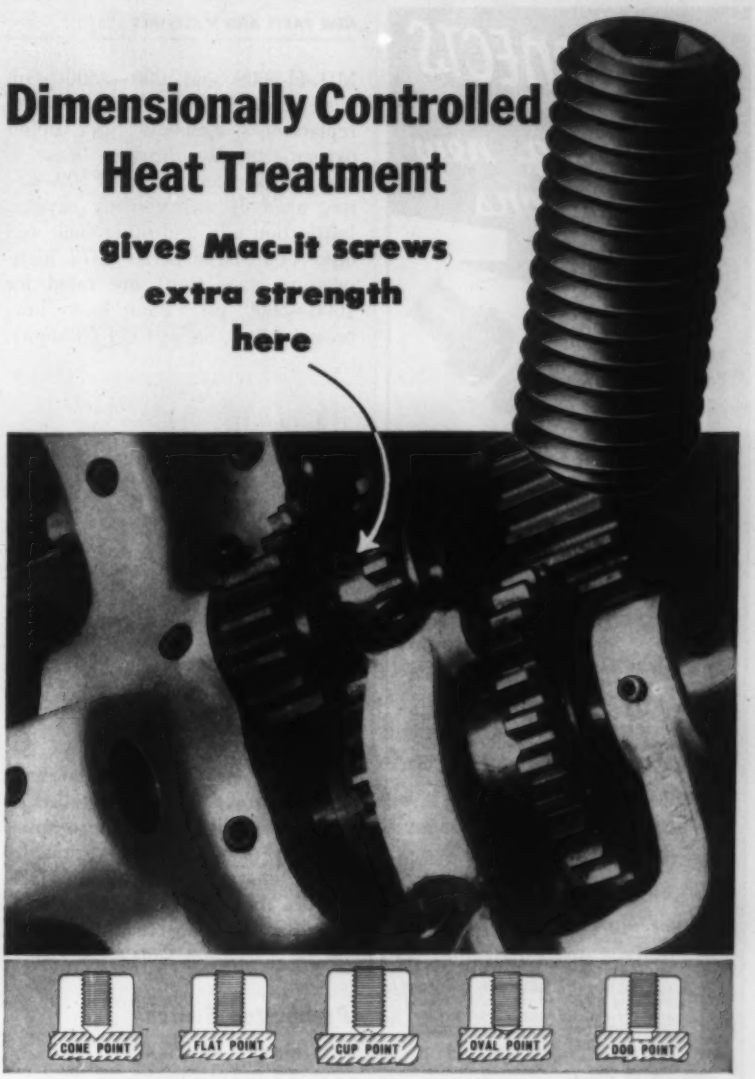
Filter Assemblies

high and low-pressure units have replacement elements

Two lines of T-type in-line filters and replacement elements have filtration ratings from 2 to 250 mu. They are available for high and low-pressure applications from −350 to +350 F temperatures, and cover flow ranges from 1—24 gpm with

Dimensionally Controlled Heat Treatment

gives Mac-it screws extra strength here



Speed, vibration, stress are tough operating conditions that extra strong, extra resilient Mac-it set screws handle with amazing ease. These high quality screws are made of special pre-tested alloy steel, produced with clean, sharp, fully formed threads and points.

Controlled heat treatments, based on material, physical dimensions and end-use, mean that Mac-it set screws resist upsetting of the points and rounding out or splitting of the hex sockets. This guarantees screws that can be set and re-set again and again with confidence. They are available with cup, flat, cone, oval and dog points so that you can select exactly the style you need.

The interest, skill and care of Mac-it specialists is your assurance that every Mac-it screw will give you the service you want—every time. That's why we say, choose Mac-its . . . *they hold tight in tight places!*

Buy by name from your distributor—buy Mac-it.

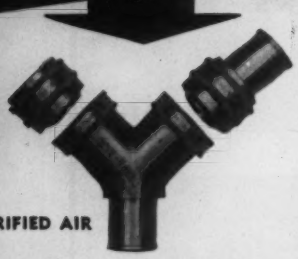
NEW SPECIFICATION SHEET listing new 1960 Series Industry Dimension Standards for socket head cap screws. Write for your *free* copy.

Mac-it Parts Co., Dept. 21, Lancaster, Pa.

MAC-IT ALLOY STEEL SCREWS

Circle 491 on Page 19

DISCONNECTS
Exploring new Horizons



PURIFIED AIR

Full line flow into "Y" socket. Metering orifices in socket permits supplying required air for one to six outlets.

LIQUID OXYGEN

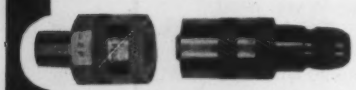
Double shut-off type with modified bayonet locking. Metal to metal seals operating against 75 PSI, minus 310°F. Meets A. F. specs.

MINIATURE COUPLING

Weighing only 1/4 oz. with 7/16" OD and 1-1/8" OAL, this aluminum coupling designed for 1/8" tubing connections to missile motor. Easy Pulomatic ball detent locking action.

COMB. OXYGEN & ELECTRICAL

Connects oxygen and communications wiring to pressurized flying suits, survival kits and capsules. Seal engages and disengages before electrical contacts.



FUEL CHARGING

Straight-thru type with fast Pulomatic ball detent locking. Unique design permits high pressures, light weight construction and flush mounting.

REQUEST CATALOG 1200A

P.S.C. offers you custom design service. We invite your envelope specification requirements.

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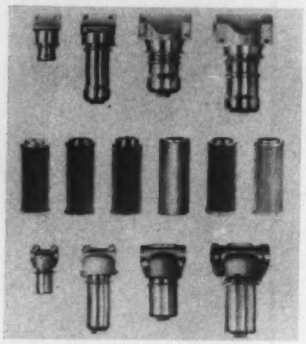
Baltimore Buffalo Chicago Cleveland Camden Los Angeles New York Providence Montreal Toronto Hamilton Canada

Circle 492 on Page 19

MIL-H-5606 and 200—2500 scfm with air at 3000 psi. Assemblies and replacement elements filter liquid oxygen, liquid nitrogen, aviation gasoline, kerosene, Skydrol 500, water, alcohol, air, gaseous oxygen, lubrication oils, and other fuels and oils. Four basic Series 2872 high-pressure sizes (top) are rated for 1000—5000 psi. Four basic low-pressure sizes, Series 6234 (bottom),



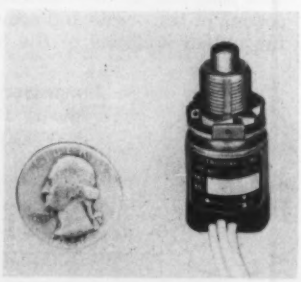
are designed for 150—2500 psi. Series 6235 replacement elements (middle row) can be installed in both low and high-pressure units. They are available with various filtering characteristics. **Filter Div., Bendix Aviation Corp.**, 434 W. 12 Mile Rd., Madison Hts., Mich. H

Circle 657 on Page 19

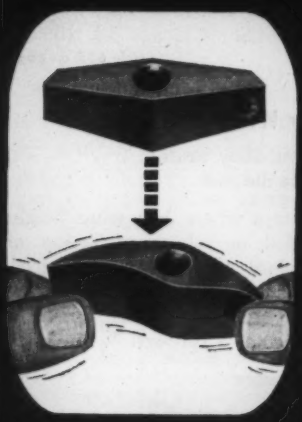
Pushbutton Switch

miniature unit is environment-free

Over-all dimensions of sealed pushbutton switch are ¾ in. diameter and 1½ in. height. Combination of O-ring in pushbutton-plunger stem and potting around leads seals out dirt, moisture, and oil, permitting switch to operate dependably regardless of environment. Scraper built into stem prevents ice and dirt from fouling plunger. Corrosion-resistant construction is used



just to *stretch* a point.



. . . Next time specify
INVESTMENT CASTING

Parts design becomes as flexible as wax when you specify Investment Casting. Because with this "lost wax" process, parts can be designed for function; for utmost operating efficiency rather than compromised to satisfy a method of manufacture.

Costly machining and assembly operations are reduced and often eliminated. Complex and time consuming tooling setups too! And — you have the widest selection of alloys from which to choose: the non-ferrous group, the carbon and low alloy steels, the hard-to-form, hard to machine high alloy steels . . . even cobalt base alloys.

Thus you stretch your design potential, you stretch your range of metals and you stretch your budget when you specify this process.

It might stretch your imagination too, if you could see some of the intricate shapes we're casting here at Hitchiner. If you'll write us today for our free new brochure, you'll get an idea how you can utilize the freedom and savings offered with Investment Casting.

For complete details, see this new illustrated, informative booklet on the art of Investment Casting. It could be the best investment you ever made.

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MANUFACTURING COMPANY, INC.
MILFORD 42, NEW HAMPSHIRE
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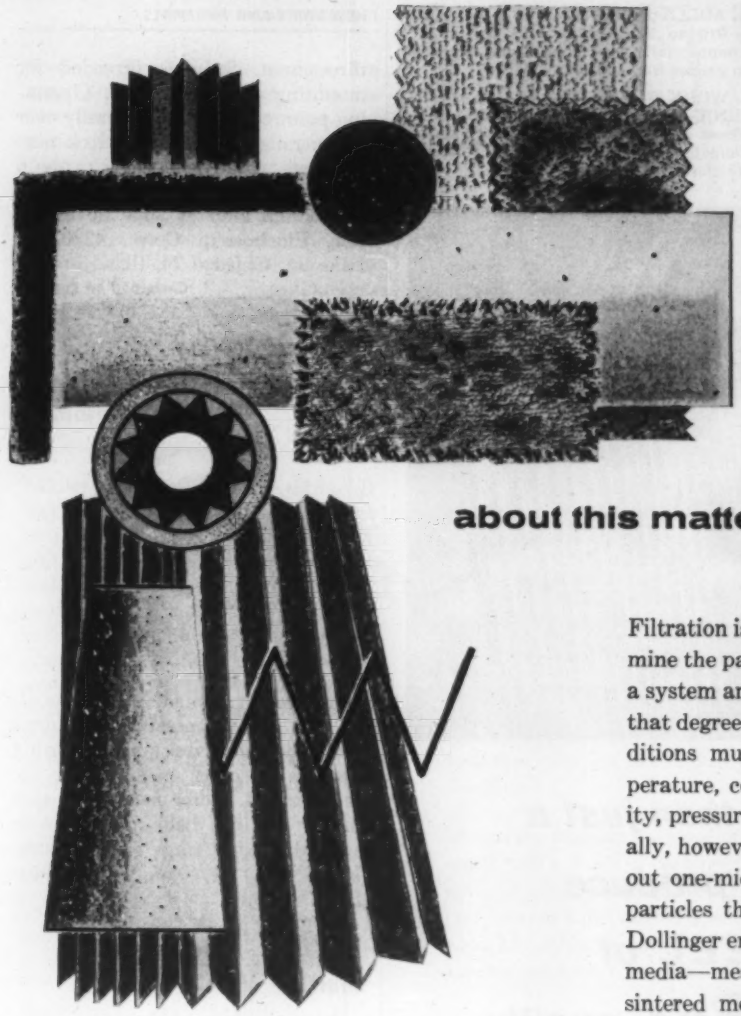


about this matter of filter media...

Filtration is all a matter of *degree*. You determine the particle size that can be tolerated in a system and then use a medium which gives that degree of filtration. Of course, other conditions must also be considered, i.e. temperature, corrosiveness, rate of flow, viscosity, pressure, allowable pressure drop. Basically, however, it's whether you want to filter out one-micron particles or strain one-inch particles that first determines the medium. Dollinger engineers make use of 110 standard media—mesh, woven cloth, felt, porous glass, sintered metals, paper, activated charcoal, etc. From this vast array, the most practical and economical medium can be selected and engineered into a unit which will meet all your filtration requirements.

Why not give us the facts, and see if Dollinger's 35 years' experience can help you? Who knows, a standard Dollinger Filter may be tailor-made for your job. Write for new composite catalog. Dollinger Corporation, 26 Centre Park, Rochester 3, N. Y.

PROTECTOMOTOR

STAYNEW FILTERS

DOLLINGER

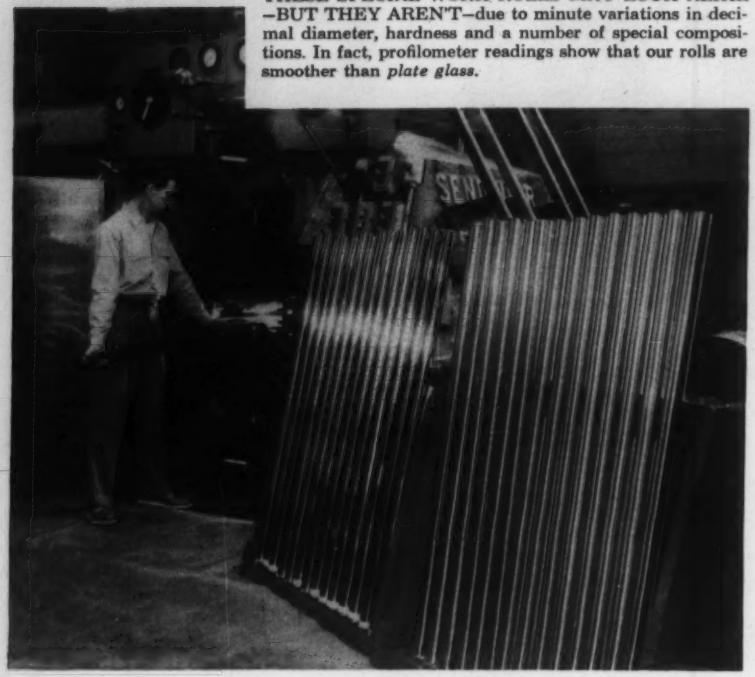
SPECIALIZING IN DRY TYPE FILTERS FOR 35 YEARS

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS • HIGH PRESSURE FILTERS • AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

Circle 494 on Page 19

OUR SENDZIMIR MILLS produce sheets up to 48" wide, in thicknesses from .010" to .109", and .005" to .109" in 36" wide sheets in all commercial grades, finishes and tempers. Strip is available in gauges from .0015" to .090".

THESE SPECIAL WORK ROLLS MAY LOOK ALIKE —BUT THEY AREN'T—due to minute variations in decimal diameter, hardness and a number of special compositions. In fact, profilometer readings show that our rolls are smoother than *plate glass*.



It takes more than just a precision mill to produce

STAINLESS STEEL *of*

MicroRold® quality

. . . it takes Operating Know-How. Only Washington Steel, *first to use Sendzimir sheet rolling, can offer you 10 years of practical experience with these mills.*

Every hot-rolled stainless steel band has variations in thickness and surface characteristics which must be compensated for in the cold-reduction process to obtain precise gauge and flawless surfaces. To do this, special work rolls with minute diameter differences along the length of the roll are used in controlling such variations as crown, edge and camber. To accurately control all the possible variations requires a large number of these rolls, plus *highly skilled operators* who know from experience which rolls, speeds and reductions are required. These are but a few of important factors in quality rolling which can only be learned by *long* experience and association with precision mills.

Washington Steel is the only producer whose entire production stainless steel sheet and strip is rolled exclusively on the Sendzimir Mill.

WASHINGTON STEEL CORPORATION

5-E Woodland Avenue • Washington, Pennsylvania

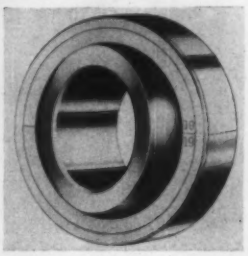
Circle 495 on Page 19

throughout. Stem is threaded for mounting in ½-in. holes. Operating point can be adjusted easily over ½-in. range by means of lock nuts on stem. Electrical capacity is 6 amp at 125 v ac and 30 v dc resistive; 2.5 amp at 30 v dc inductive. **Electrosnap Corp.**, 4220 W. Lake St., Chicago 24, Ill. J

Circle 658 on Page 19

Spherical Bearing

for high-temperature applications



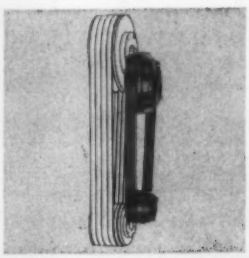
New bearing is made of various alloys for high-temperature conditions and corrosion resistance. Bearing surfaces of outer member are radius ground. Outer member is split in two sections held together with swaged locking rings on each side. **Heim Co.**, 20 Sanford St., Fairfield, Conn. B

Circle 659 on Page 19

Multiple V-Belts

have tensile member above belt V-section

Increased sidewall area, plus a domed top which frees entire sidewall for power transmission purposes, are features of No. 358 V-belts. Placement of tensile member above V-section of belt insures that all of sidewall area is under compression. New strength member makes possible 40 per cent reduction in number of cross-sections needed for multiple drives, so that



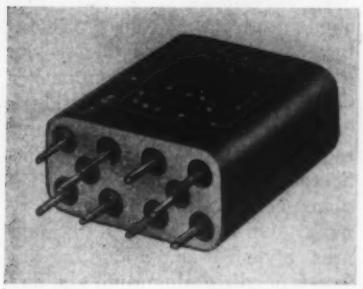
three sections of belts cover entire range of multiple drives. Sheaves incorporate narrower grooves and closer groove spacing than previous units. Synthetic rubbers are used in belts to make them resistant to heat, oil, and grease. Rubbers are highly flex resistant to provide maximum belt life. Belts are manufactured in 3, 5, and 8-V sizes. **Durkee-Atwood Co.**, 215 Northeast 7th St., Minneapolis 13, Minn. J

Circle 660 on Page 19

Miniature Relays

for automatic assembly use

Miniature relays have terminals located on 0.2 x 0.2-in. co-ordinates to permit mounting on printed-circuit boards by automatic assembly techniques. Terminal layouts are available on both dual-coil magnetic-latching and on single-coil-action relays. Both units operate under 100 g shock and 30 g vibration to 2000 cps with no contact openings in either armature position. Relays with single-coil action pull in at 260 mw at 25 C; dual-



coil units pull in at 230 mw. Single-coil action SCG relays have eight pins located in two rows of four. Magnetic-latching units have ten pins. Both units have DPDT contacts rated at 2 amp, 28 v dc, resistive. **Technical Information Dept., Potter & Brumfield Inc.**, Princeton, Ind. J

Circle 661 on Page 19

Laminated Plastic

for printed-circuit applications

Premium grade epoxy-paper base laminated plastic, designated phenolite EP-491, features excellent flame resistance, good cold-punching quality, electrical properties superior to

IN A DESIGN SQUEEZE?

OPEN UP

...with the all-new PM-1 line of permanent-magnet d-c motors for your hard-to-fit applications. Only ⅞ inches in diameter, under 2 inches long and weighing less than 2½ ounces, these motors give you equivalent output power with ⅓ less bulk than older designs. And they're self-shielding.

Motors are available governed or ungoverned, with a choice of bearings, shaft extensions, and mounting arrangements; gear motors with various speed reductions. Modifications can be made to meet military and other special requirements.

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● CERAMIC FIELD STRUCTURE ● SELF-SHIELDING
● SPEEDS TO 20,000 RPM ● VIBRATION- AND SHOCK-RESISTANT

WRITE TODAY for complete specifications, including information about Reflectone's unique self-contained POWER-PAK, a complete, compact electromechanical subassembly to simplify your design problem. One component provides mechanical output and d-c power for associated circuitry from AC, DC or self-contained battery.

"THE D-C WAY IS THE MODERN WAY"

Design d-c for maximum flexibility, portability, simplicity and dependability.

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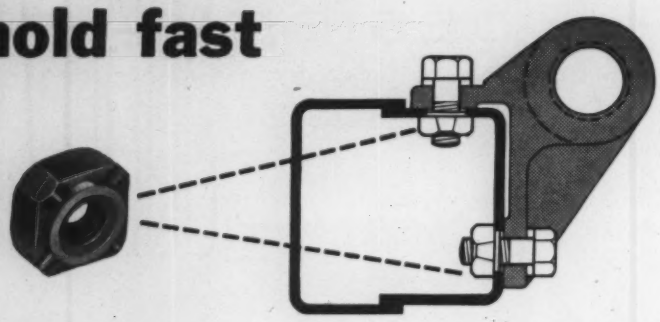
Circle 496 on Page 19

MIDLAND
WELDING NUTS
hold fast

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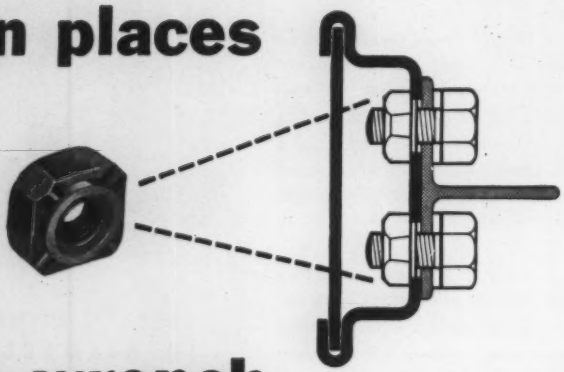
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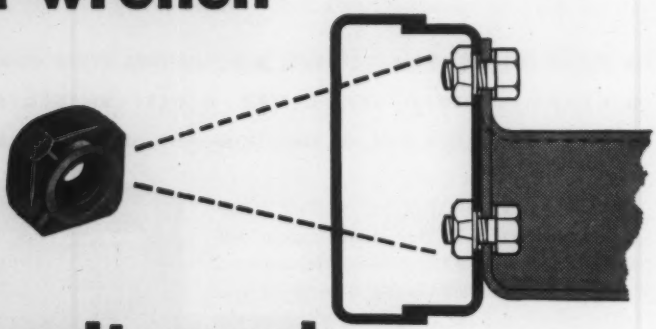
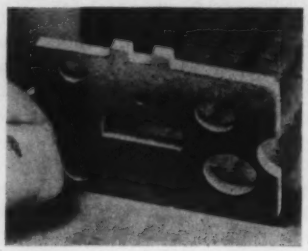

can't reach

Looking for cost and time-saving tips? Send for the free booklet showing you how to "Save With Midland Welding Nuts."

MIDLAND-ROSS CORPORATION
OWOSSO DIVISION • OWOSSO, MICHIGAN

MIDLAND WELD NUT

Circle 497 on Page 19



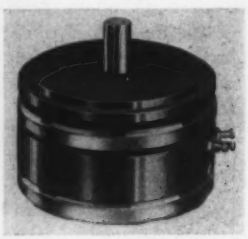
regular XXXP types, and dimensional stability better than XXXP types. Laminate meets printed-circuit requirements for use in computers. Copper-clad form has application in electronic gear for aircraft and missile use, as well as in other military applications. Material is available in thickness from 1/32 to 1/4 in., in sheet sizes 39 x 47 in. and 39 in. square. **National Vulcanized Fibre Co.**, 1059 Beech St., Wilmington 99, Del. C

Circle 662 on Page 19

Long-Life Potentiometer

withstands high cycling speeds

Special winding technique which eliminates metal fatigue of winding from action of wiper produces long life in Model L1750 potentiometer. Other features include resolution to 0.027 per cent and total resistance ranges from 5000 to 75,000 ohms. Special resistance range of 100,000 ohms can be provided upon request. Unit meets NAS-710 Standards, Style RR-18. Mounting surface is anodized aluminum and cups and rear cover are precision molded



of shock and humidity-resistant plastic. Long life, low noise, low torque, and ability to withstand high cycling speeds make unit suitable for installations that are difficult to maintain. **G. M. Giannini & Co. Inc.**, 918 E. Green St., Pasadena 1, Calif. L

Circle 663 on Page 19

ENGINEERING DEPARTMENT

EQUIPMENT

Temperature Test Chamber

has range of −100 to +500 F

Having a test volume of 10 x 7 x 7 in., Model 6545R temperature test chamber occupies only 10½ in. height in standard 19-in. rack. Temperature range is from −100 to +500 F. Unit is especially useful where several chambers are needed or where bench space is limited. Sensitive, direct-reading thermostat automatically controls temperature within ±2 F at any point in range. Low temperatures are attained

rapidly by injection of liquid CO_2 through solenoid-operated valve. Built-in heating element provides high temperatures. Unit operates on 117 v ac, and incorporates centrifugal blower to assure temperature uniformity throughout test space. Standard test drawer contains ten feed-through sleeves and stainless-steel inside tray. Test space is fully insulated with low conductivity inorganic fiber. **Delta Design Engineers Inc.**, 7460 Girard Ave., La Jolla, Calif. F

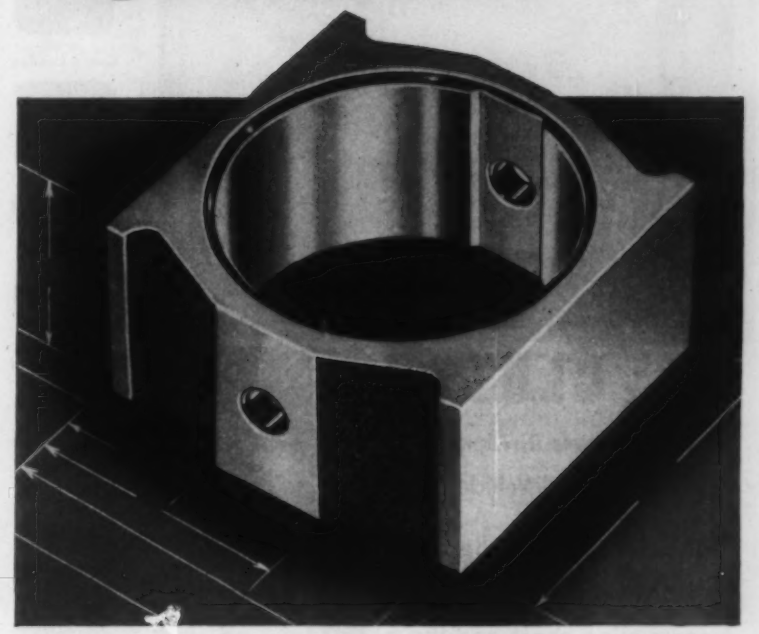
Circle 664 on Page 19

Tracing Paper

has excellent dimensional stability

Of 100 per cent rag content, V-600 Vindure prepared tracing paper has high ghost resistance, strong ability to withstand normal drafting room handling, and high transparency. Paper is impervious to buckling because of exceptional dimensional stability. Recommended for use with

many difficult requirements...



We illustrate the cast bronze cam block for a hydraulic pump operating the hydraulic lift mechanism on an exceedingly well-known line of farm tractors.

The manufacturer of this equipment has very unusual specifications for this cam block. Its bore has a very fine finish specification. It also must be round and true to size within unusually close limits. In addition, it must be square to the face of the cam block within limits that ordinary methods of manufacture will not attain.

Bunting methods of manufacture result in a part which is completely to the customer's exacting specifications.

For the unusual, as well as the usual, in bearings, bushings, bars, or special parts of cast bronze, sintered metal, or Alcoa aluminum, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

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Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

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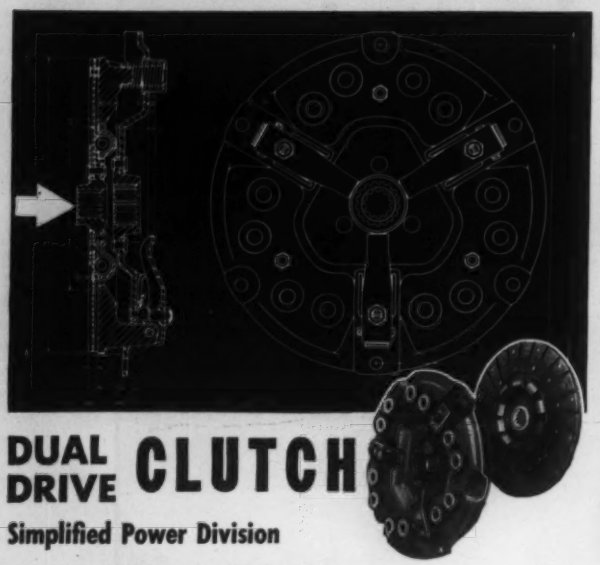
BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE OR SINTERED METALS. ALCOA® ALUMINUM BARS

Circle 498 on Page 19

ROCKFORD



DUAL DRIVE CLUTCH

Simplified Power Division Between PTO and Vehicle Drives

This is a foot-controlled, spring-loaded clutch of rugged construction. It drives both the vehicle transmission shaft and the power take-off shaft. Power is transmitted to the power take-off by a hollow shaft, driven by a splined hub in the clutch cover plate. This hollow shaft operates at all times the engine is running. The vehicle transmission shaft operates inside the hollow shaft. This Dual-Drive design results in dependable control and transmission of full engine power to vehicle driving-wheels and power take-off.

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

311 Catherine St., Rockford, Ill., U.S.A.

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ROCKFORD B-W BORG-WARNER

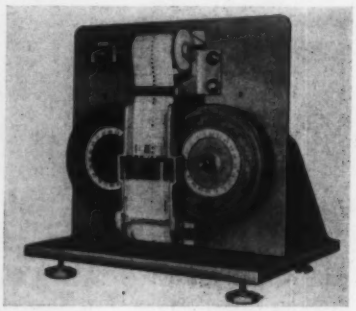
CLUTCHES

4H pencil for general drafting, paper resists ghosting even with 8H pencil. It does not fuzz and retains writing quality after many pencil or ink erasures. Paper resists moisture, can be dipped in water without showing loss of any qualities when dried, and does not yellow with age. It is available in rolls of 30, 36, and 42-in. width. Cut sheets are also available, plain or printed with title block and border line. Cross-sectional ruling of 4 x 4, 5 x 5, 8 x 8, and 10 x 10 to the inch is also furnished. **George Vincent Inc.**, 95 Industrial Ave. E., Clifton, N. J. D

Circle 665 on Page 19

Analog-to-Digital Recorder

has low input torque requirements



Shaft-input analog-to-digital recorder records analog values in binary-decimal punched-tape form. Tape can be read directly or translated automatically into standard punched cards or tape for computer processing. Unit simultaneously supplies digital information in form of electrical contacts that can be used for telemetering. Input torque requirements are low, so that usually measured variable can be used to drive shaft directly. Where available torque is insufficient, or signal is in electrical form, recorder can be used with a servo system to record flow, pressure, temperature, and other analog values. Unit can also be used with a solenoid and ratchet wheel to count pulses during any given time period, as in traffic or production counting. Recorder can be operated from commercial power supplies or by battery. **Fischer & Porter Co.**, 116 Jacksonville Rd., Hatboro, Pa. E

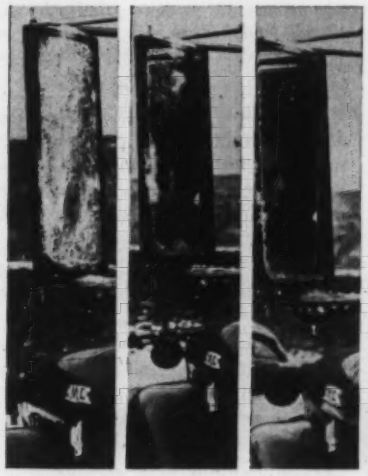
Circle 666 on Page 19

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

NEW! A MIRROR THAT MAKES HEAT TO BEAT SLEET

You're jockeying a big trailer-truck along a winding road in New England. It's winter and you run into a real storm—a mixture of snow, rain, sleet. You flip a switch and . . .



Your outside rear-view mirror is *clear* in a matter of minutes. From a heavy coating of ice to *all* clear is only a matter of five minutes, even at −20°F.

The mirror, as you might guess, isn't just ordinary glass. It's one of Corning's PYREX brand glasses, and on its surface is an electrically conductive coating that's permanently fired in.

This coating (a metallic oxide) is what turns your mirror into a *heating* element when a current is applied. The heat melts ice and snow, prevents fog or drizzle from condensing on the surface.

If you use EC (electrical-conducting) glass for self-defrosting mirrors you get a bonus, since the coating also provides a non-glare surface.

But don't go away just because you gave up dreaming about driving a truck-and-trailer years ago. This PYREX® electrical-conducting glass comes in a wide choice of applications.

For example, there are some enterprising people who build radiant heaters, both portable and permanent, around such glass panels.

Comfort, safety, and convenience are the big selling points. Comfort because a panel of EC glass is an area *heat* source putting out long waves. Safety because there are no exposed wires or moving parts. Convenience since you have no burning, no need to do extensive remodeling in order to install it.

These same reasons have made PYREX brand radiant heating units attractive to industry—for heating, drying, curing, baking.

And, if you turn a panel of this glass *around*, it becomes an infrared reflector you can see through—blocking heat but still passing about 75% of the visible light.

Facts? Ask for PE-34, a 4-page data sheet, and/or PE-60, all about industrial heating units. Please use the coupon.

YOU ARE CORDIALLY INVITED

. . . to visit the Corning Glass Center located in Corning, in the rolling hills just south of New York State's Finger Lakes region. The Center is dedicated to the history, science, art, and industry of glassmaking.

Among the Center's most-visited attractions are the Corning Museum of Glass and the Hall of Science and Industry.

At the Museum you'll find a comprehensive and renowned collection of glass *objets d'art*. You will find vases and other glass forms produced by by-gone civilizations. And you will see the ways in which today's craftsmen, around the world, use glass in varied art forms.

The Hall of Science and Industry is filled with exhibits and devoted to the roles glass plays in industry, business, and science. Many exhibits contain full-scale working models and demonstrations.

And, there's also a library devoted exclusively to books and other reference materials on glass.

It all awaits you. So come to the Glass Center. You'll find it stimulating and rewarding. Bring the family, too. You'll all enjoy the trip.

Open daily except Mondays from 9:30 to 5.

If you'd like a few more facts, send for a free folder. But plan to come soon.

HOW TO GET A RECTANGULAR BEAM FROM A ROUND LENS

This is no ordinary floodlight lens. It produces, despite its circular shape, a rectangular beam.

Why? Because a large oil company asked Crouse-Hinds of Syracuse, N. Y., to provide a floodlight to illuminate rectangular signs, 4′ x 8′. Besides being rectangular, the request called for lighting that had no "hot spot" which might make the sign unreadable.

So Crouse-Hinds turned to Corning. And through the talents of one of our product engineers, we designed a *round* lens that puts out a rectangular beam.

Unusual? Yes, but typical of the special problems we handle almost daily (we once made a lens producing a square beam for the same people).

Moral: Whatever your interest—be it lighting, corrosion, high temperatures, precision shaping, or what have you—maybe we already make what you need from glass.

As a start, take a look through "This Is Glass." (To get a copy, check the coupon.)

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 52 Crystal Street, Corning, N.Y.

Please send me: ☐ PE-34, 4-page data sheet on glasses for industrial use; ☐ PE-60, booklet on heating units; ☐ Brochure on the Glass Center; ☐ "This Is Glass"

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Recent Books

Materials for Rockets and Missiles. *By Robert G. Frank and William F. Zimmerman; 124 pages, 5 by 7½ in., clothbound; published by and available from The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; $4.50 per copy.*

This book contains engineering data for lightweight, high-temperature materials now available. Materials expected to become available in the next few years are previewed. Materials covered are sheet, wrought, and cast alloys having iron, nickel, and cobalt as base metals.

Wrought and cast alloys of aluminum and magnesium, titanium and molybdenum alloys, cermets, and ceramics are also discussed. Chapters are included on materials fabrication and interpretation of the 10 and 100-hr stress-rupture strength data presented.

Basic Hydraulics—Learner's Manual. *95 pages, 8½ by 11 in., ringbound; edited by and available from Instructional Materials Laboratory, Ohio State University, Columbus 10, Ohio; $2.00 per copy.*

This workbook presents fundamentals and their basic applications. Problems and questions, including questions on material in three basic reading references, illustrate the theories involved. Symbols and diagrams for hydraulic circuits and related mathematics are reviewed. Circuits, fluids, control devices, basic hardware, heat exchangers, filtration, and maintenance are discussed.

Dictionary of Guided Missiles and Space Flight. *Edited by Grayson Merrill; 688 pages, 7¼ by 10 in., clothbound; published by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; available from* MACHINE DESIGN, *$17.50 per copy postpaid.*

Serving both as dictionary and encyclopedia, this book defines terms commonly used in missile and

space work. Combinations of exact definitions, detailed explanation or discussion, diagrams, and illustrations are used where better understanding will result.

Words and terms covered are names of missiles and spacecraft; guidance, control, propulsion, armament, and launching systems; and systems components. Related terms from aerodynamics, astrodynamics, electronics, astronomy, and physics include items such as antennas, circuits, radars, rockets, and propellants, as well as important laws, relationships, equations, and concepts which govern their application and design.

Government Publications

OTS Technical Reports. *Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

PB 131943. Research and Development on Determination of Coefficients of Friction Between Dry Metallic Surfaces. By Eber W. Gaylord and Hunter Shu, for Watertown Arsenal Laboratory; 48 pages, 8 by 10½ in., paperbound, side-stapled; $1.50 per copy.

Coefficients of static friction are determined for mild steel rubbing on mild steel, titanium RC 130B on mild steel and uranium, and uranium on uranium and beryllium for both statically and dynamically applied loads. Normal rubbing pressures range from 1500 to 12,000 psi for statically applied loads and from 12,000 to 21,000 psi for dynamically applied loads.

Coefficients of kinetic friction are determined between various metals for rubbing speeds of 30 to 50 fps and rubbing pressures of 1600 to 3000 psi.

PB 151451. A Research Program on the Investigation of Seal Materials for High Temperature Application. By Raymond H. Baskey, for WADC; 64 pages, 8¼ by 10¾ in., paperbound, stapled; $2.00 per copy.

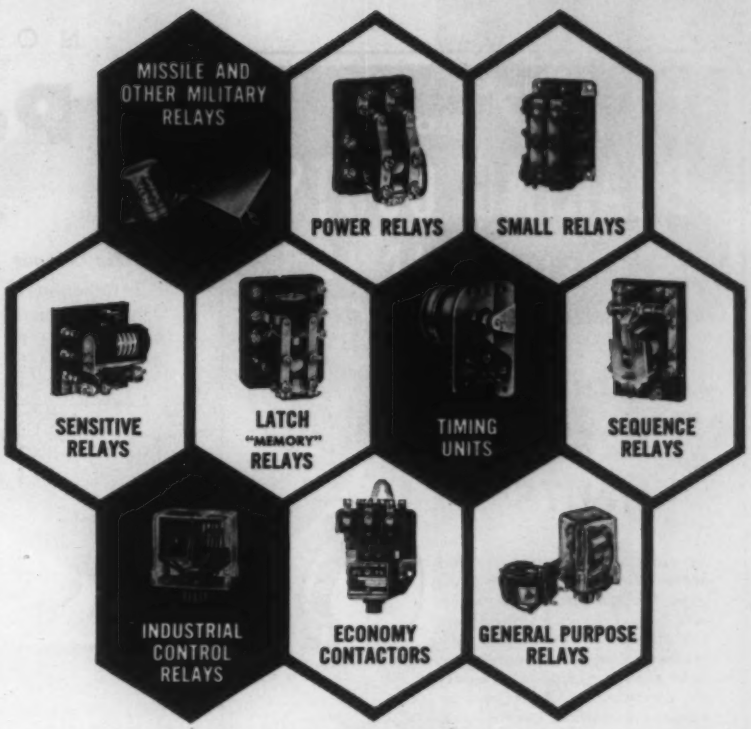
High-speed tests were conducted in ambients up to 1350 F, at 30,000-fpm sliding speeds, with loads up to 14 psi, and with no external lubrication. Sliding friction between high-temperature steels, stainless steel, and Inconel and seals of pure refractory hard metals (carbides, borides, nitrides, silicides) is investigated. Promising materials were combined with nickel and tested. Best of this group received silver additions for repeat testing.

Graphite seals, protected from oxidation by impregnation with various compounds and with or without zirconium-carbide coatings, were run against type 303 stainless steel and Kentanium K162B at 14,000 fpm, 16 psi, and up to 1100 F.

PB 151483. A Study of Refractory Materials for Seal Bearing Applications in Aircraft Accessory Units and Rocket Motors. By L. B. Sibley, C. M. Allen, W. J. Zielenbach, C. L. Peterson, and W. H. Goldthwaite, for WADC; 52 pages, 8¼ by 10¾ in., paperbound, stapled; $1.50 per copy.

Commercially available ceramic, cermet, and high-temperature alloy materials are evaluated for corrosion resistance and for friction-wear behavior in an oxidizing atmosphere from 1000 to 1800 F. Rubbing-wear experiments were conducted at 200-fpm sliding speed under approximately 20-psi load pressure. Wear-failure mechanism is described. Some correlation of experimental results with conventional thermal-stress-resistance parameters is obtained.

Two rubbing-wear experiments were conducted in a high-temperature reducing atmosphere. Static corrosion resistance of several materials was determined in a nitric acid oxidizer. Some of the experimental ceramic and cermet materials fabricated are evaluated for rubbing-wear in the oxidizing atmosphere.



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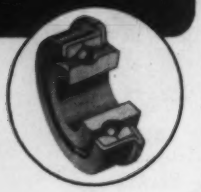

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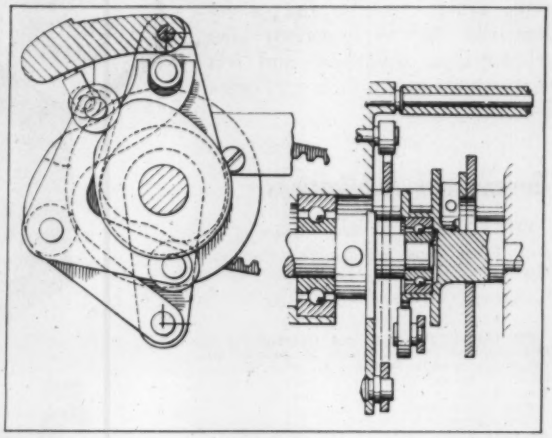
Patents

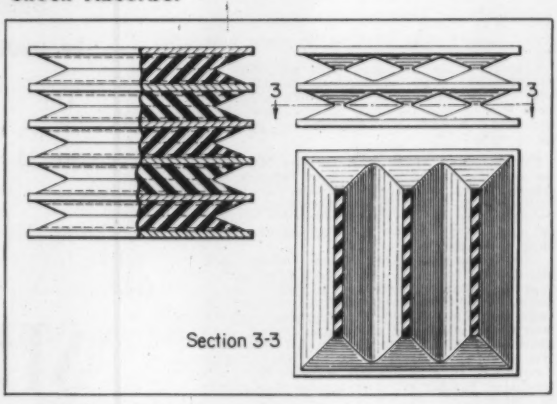
Cyclic-Output Drive

Interaction of members in a rotary feed assembly, driven at constant speed, controls inertia forces to prevent damage to cards fed one at a time from the bottom of a stack. A U-shaped link is connected at one



end to a constant-speed crank. At the other end, a fork engages a pin to drive a stepped card-picking member. The U-link is pinned to and pivots with a V-shaped link which rides a pair of stationary, complementary cams. Movement of the links, as determined by the cams, starts the cards from rest at low velocity and low acceleration. *Patent 2,880,996 assigned to International Business Machines Corp., New York, by Donald J. Stiles.*

Shock Absorber



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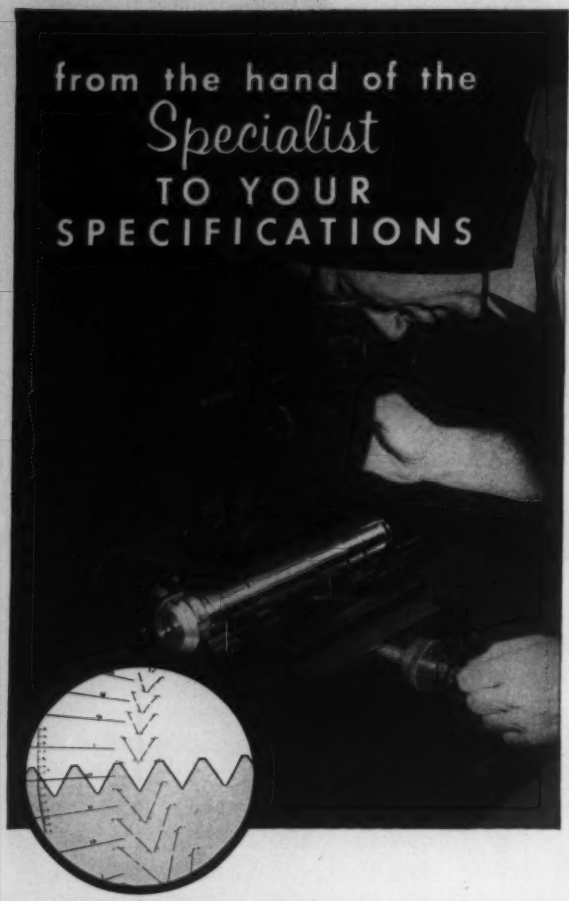

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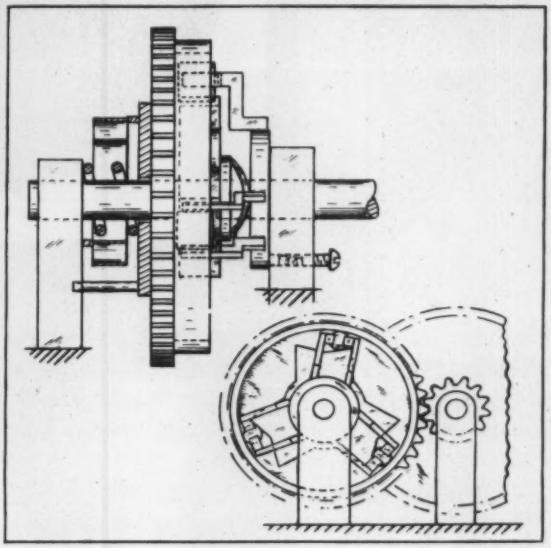
Circle 505 on Page 19

through the rubber enable the cushion to compress to 48 per cent of its free length before the rubber fills the diamond holes and reaches the edges of the plates. *Patent 2,880,885 assigned to National Malleable Castings Co., Cleveland, by Donald Willison.*

Antibacklash Gear Assembly

In either direction of rotation, a driving-gear assembly winds a spiral torsion spring which takes up backlash when rotation is reversed. The driving gear is free to rotate about its shaft. It carries a ring which



is engaged by rollers wedged radially by one side of V-slopes on a spider fixed to the power shaft. The torsion spring, which is fixed to a stationary support at one end, and to a friction disc at the other end, is wound or unwound one turn or less when the driving gear rotates. The friction disc is loaded axially by a helical spring. When rotation is reversed, the torsion spring drives the assembly, through the friction disc, until the gear is engaged by the rollers wedged by opposite arms of the V-slopes. *Patent 2,880,625 assigned to Industrial Controls Corp., Chattanooga, Tenn., by Albert G. Thomas.*

Adjustable Fluid-Pulse Valve

Pressure pulsations, in either liquid or gas circuits, are provided by a valve assembly having two kinds of controls. Fluid entering the valve flows into the tubular end of a constant-speed shaft. A slot in the tube wall passes fluid to discharge. Coaxial with the shaft is a gear segment having a sleeve with a contoured edge surrounding the slotted tube. Motion of an external control crank changes the length of slot exposed, to control flow volume or amplitude. Regulation of shaft speed controls pulse frequency. *Patent 2,880,760 assigned to Bendix Aviation Corp., South Bend, Ind., by George M. Widell and James M. Eastman.*

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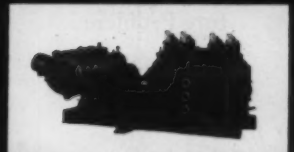

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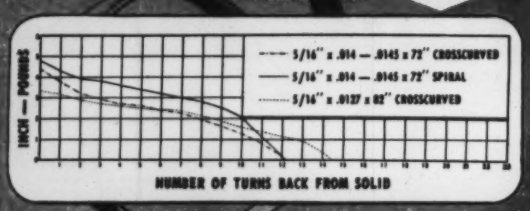
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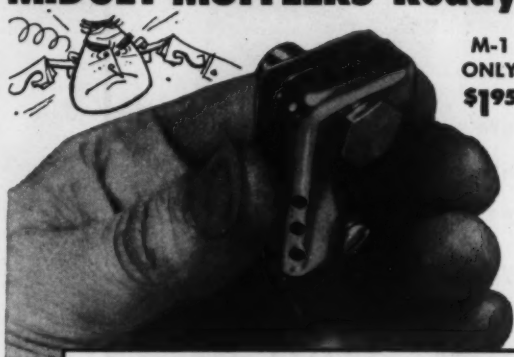

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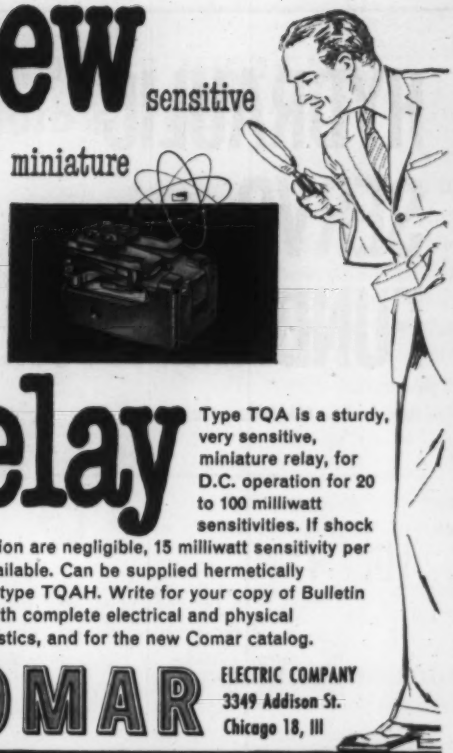

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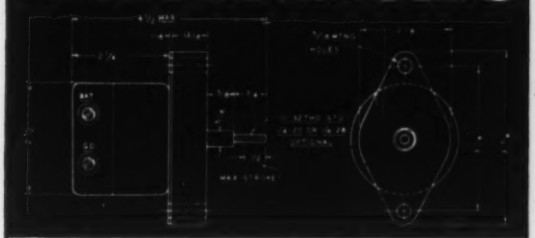

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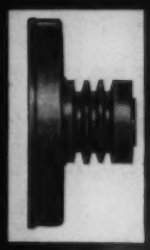

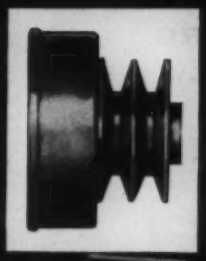

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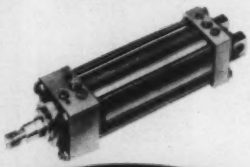

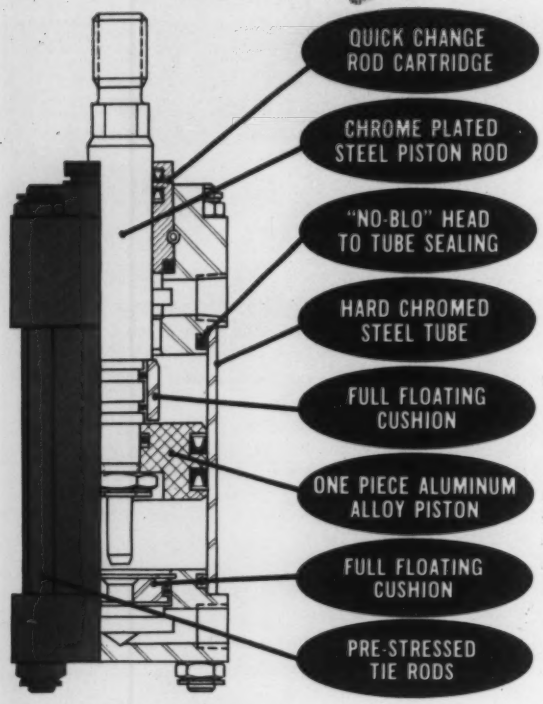
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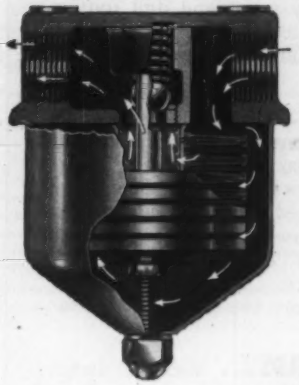

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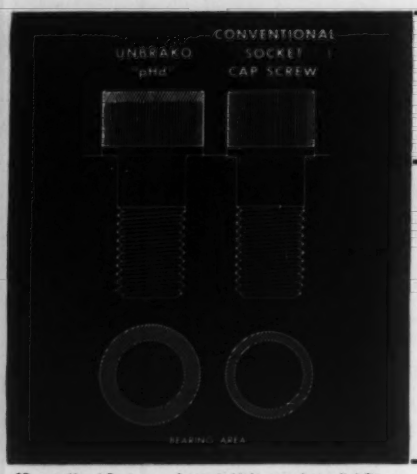

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SCREW SIZE	HEAD DIAMETER (in.)		BEARING AREA (sq. in.)		LOAD TO INDENT IN CAST IRON (lb.)		% INCREASE USABLE STRENGTH	TIGHTENING TORQUE (lb.-in.)‡	
	Old	pHd	Old	pHd	Old	pHd		Old	pHd
¼	.375	.375	.041	.041	3,280	3,280	—	165	180
5/16	.438	.468	.047	.072	3,760	5,760	54	325	360
3/8	.562	.562	.102	.102	8,150	8,150	—	600	660
7/16	.625	.656	.116	.148	9,270	11,800	27	1,000	1,040
½	.750	.750	.188	.188	15,000	15,000	—	1,450	1,590
5/8	.875	.937	.203	.305	16,200	24,400	51	2,900	3,190
¾	1.000	1.125	.223	.432	17,800	34,600	94	5,050	5,600
7/8	1.125	1.312	.254	.594	20,300	47,500	134	8,000	8,900
1	1.312	1.500	.364	.785	29,100	62,800	116	10,550	13,600

*Proper Head Design—a factor in higher product reliability.

‡Normal recommended seating torques for unplated screws, fine threads.

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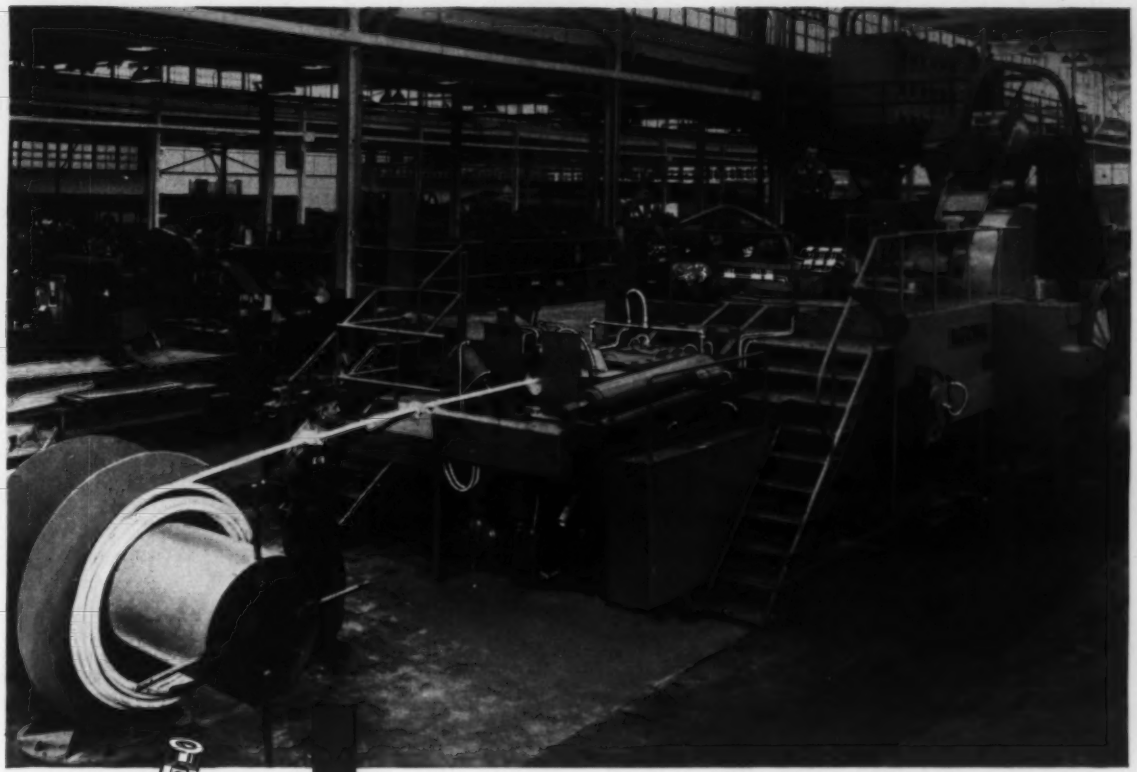

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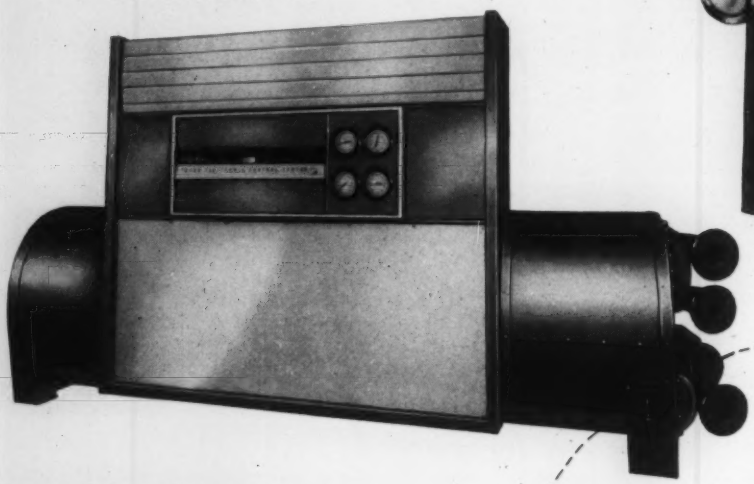
The York Corporation, subsidiary of Borg-Warner Corp. provides Cutler-Hammer Control on the Turbopak Centrifugal Water Chilling System. The completely integrated Turbopak system simplifies installation, maintenance, and operation.



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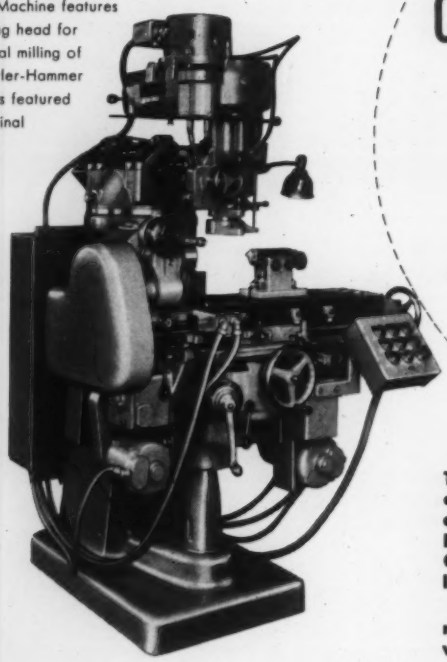

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